REPORT RESUMES

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LIFE AND EARTH SCIENCE, JUNIOR HIGH SCHOOL.

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CURRICULUM GUIDES FOR GRADE 7 "LIFE SCIENCE" AND GRADE 8 "EARTH SCIENCE" WERE DEVELOPED BY 24 AREA TEACHERS AND THREE SAM HOUSTON STATE COLLEGE PROFESSORS. THE PROJECT WAS SUPPORTED BY THE TEXAS SMALL SCHOOL ASSOCIATION, THE LOCAL SCHOOLS, AND FUNDS FROM THE TITLE III PROGRAM. THE TEACHER GUIDES WERE PREPARED TO IMPROVE THE JUNIOR HIGH SCHOOL SCIENCE PROGRAMS IN THE IMMEDIATE 13-COUNTY AREA AND WERE PRIMARILY TO HELP THE TEACHER RATHER THAN TO SERVE AS A DIRECT STUDENT AID. THE PRINCIPAL CONCERN WAS TO PROVIDE ADDITIONAL BACKGROUND INFORMATION AND GUIDANCE FOR THE NEW TEACHER, THE TEACHER TEACHING OUT OF HIS FIELD, AND THE TEACHER WHO HAD NOT YET COMPLETED A DEGREE PROGRAM. THE GUIDE ON LIFE SCIENCE HAS 12 CHAPTERS AND IS BUILT AROUND QUESTIONS THAT WOULD CONCERN AND INVOLVE A SEVENTH GRADER IN LIFE SCIENCE. THE EARTH SCIENCE GUIDE HAS 16 CHAPTERS AND THE SAME FORMAT, BUT IS DIRECTED AT GRADE 8 STUDENTS. EACH CHAPTER CONTAINS (1) STATEMENTS OF OBJECTIVES, (2) BACKGROUND INFORMATION, (3) STUDENT ACTIVITIES, (4) QUESTIONS WHICH CAN BE USED IN STIMULATING DISCUSSIONS, (5) EVALUATION QUESTIONS, AND (6) A BIBLIOGRAPHY. NUMEROUS DIAGRAMS AND CHARTS WHICH COULD BE DUPLICATED OR MADE INTO TRANSPARENCIES ARE INCLUDED. (DS)

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LIFE AND EARTH SCIENCE
Junior High School

Sam Houston State College
Education Department
Huntsville, Texas
1967

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LIFE AND EARTH SCIENCE

Curriculum Guide

Written and Compiled
by
Title III Science Workshop Participants

Sam Houston Area

Cooperative Curriculum Center for Improvement

of Educational Opportunities

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Dr. Fred Mahler, Project Director

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FOREWORD

The curriculum guides compiled within this volume represent the concerted efforts of twenty-four area teachers and three Sam Houston State College professors working with the backing of the Texas Small School Association, the local principals of the area and the Title III program. The guides were prepared to aid the junior high school science programs in the immediate thirteen county area. The substance of the guides is designed more to help the teacher rather than to serve as a direct student aid. The principal concern was to provide additional background information and guidance for the new teacher, the teacher teaching out of his or her field, and the teacher who has not yet completed his or her baccalaureate degree program.

Although research has not identified the specific characteristics of an excellent teacher we know that certain general characteristics help a teacher gain effectiveness: a strong subject matter background can build useable depth; sincere enthusiasm can be a catalyst of student interest; and personal maturity, poise, self respect, empathy, and tenacity can promote student involvement. What each student carries out of the classroom each day determines the true standing of the teacher. The teacher should be her own best critic. An ever present question should be, "How can I improve my program and my impact?"

Approach and method are very hard to include within a curriculum guide and yet the very essence of science, as a subject, being scientific depends on questioning every fact, testing hypotheses and conclusions, and holding all attained knowledge as tentative and subject to correction by further findings. How can we justify a pure reading and rote memory program? Since total knowledge of science is now doubling every five years and old findings are being modified constantly, we can no longer afford to teach by telling. With all the knowledge we have today, no one person can know all of one field, let alone all of science.

We can stimulate inquiry with open-end questions. We can guide the class to explore questions with literature review, resource persons, panel discussions, and class discussions. We can stimulate students to test possible answers with experimentation. Then as a culminating activity we can follow through with varied evaluation techniques. Foremost science educators believe that experimentation establishes kinesthetic foundation findings unequaled in strength by any other method of knowledge acquisition. We can make knowledge acquisition even more meaningful by avoiding the cookbook type of experimentation.

Our approach must be reflected in the direction of our evaluations lest we make a lie of our inquiry approach by testing for trite facts. (See the BSCS Biology Teacher's Handbook for the chapter on the construction of the classroom test.)

The format of the guide on life science is built around questions that would concern and involve a seventh grader in life science. The guide on earth science also seeks to explore the questions that intrigue and sustain the interest and effort of an eighth grader.

The guides are presented with full knowledge that final curriculum needs and decisions for a school district must and should be determined by the local school district.

The text of the guide is offered not as a finished product but as a springboard for future interchange of ideas and practices that may prove useful to all of us. We need and solicit your reactions and contributions to round out this beginning. We hope it can lead to a new high in interdistrict cooperation for the sake of the children in all of our junior high science classes in East Texas.

CHAPTER I

HOW CAN I USE SCIENCE?

Introduction

Science is a body of organized and tested but tentatively accepted knowledge. The tentative nature of each tested finding implies a continuous search for more knowledge. Most human individuals have been curious about the living and non-living things in our universe. The history of man records continuous effort toward a fuller understanding of mankind and his surroundings. Science's unique contributions have been brought into focus through removal of bias in seeking cause and effect relationships and testing conclusions with controlled repeatable experiments.

Life science is the study of all living things in relation to their environment and the interrelationship of all living things. It is such a large subject, that no one can learn all known science in a lifetime, nor can a teacher teach it all. Only a very small amount of existing knowledge can be taught in a year. Life Science is an active, dynamic field constantly demanding willingness to make new observations, to consider new facts, to challenge earlier conclusions, and to repeat experiments as long as there is a question of their veracity.

A student should be taught that once a problem is recognized and defined, a plan should be set up by which one can find, or attempt to find, the best answer to the question. Many plans are possible since there are many diverse methods which can be called scientific. One method may involve a careful search through the available literature to find what conclusions others might have reached using the same information. Eventually controlled laboratory conditions are planned to test a hypothesis. Careful observations prove or disprove any theories which have been evolved. A satisfactory conclusion should take into consideration all known facts.

The approach, called a scientific method, may vary with different problems, but, in general, the following steps may be used as a guide in problem solving in many circumstances:

1. State the problem and the conditions involved, using all available information.
2. Set up a trial hypothesis by which it is hoped a solution will be found.
3. Contrive controlled experiments to test the hypothesis.
4. Attempt to arrive at a logical, unbiased conclusion using information gained through observations.
5. If no logical answer is evolved, establish a new hypothesis and try another approach.
6. Once a conclusion has been reached, repeat the procedure several times to test the solution and prove that it holds true for the conditions which have been established.

The teacher should emphasize to students the fact that correct procedures are, in general, more important than correct answers. A scientist will more often prove a hypothesis false than true, and if the test procedure is valid, the results of disproving a hypothesis can be equally as valuable as proving a hypothesis true. Students need the freedom to formulate false hypothesis. Therefore, cookbook answers should be avoided in presenting problems to students. When the correct answer is provided, the student's endeavors may be aimed toward the answer rather than the use of sound procedures and common sense.

Life Science can be interpreted as a study of the interaction of structure, function and behavior of living things and an expression of the adaption of living things to their ecologic setting.

Objectives

1. Show students they can solve everyday problems by the scientific method which includes an objective unbiased attitude and a systematic approach.
2. Show that every effect has a cause.
3. Show that our senses are limited.
4. Show that a conclusion of an experiment, or problem, can be stated as a fact only if the same conclusion can be reached by others doing the same experiment or solving the same problem.
5. All knowledge is held as tentative subject to review when further evidence is found.

Anticipatory Reflections

1. How does the scientific method influence my everyday life?
2. What attitudes characterize science?
3. How can limitations in science be recognized?
4. What is the importance of repetition in scientific results?
5. What procedures characterize science?
6. What is a scientific method?
7. How can the development and application of scientific attitudes and methods help me gain greater understanding of myself and my problems throughout my lifetime.

Problem Solving Attitudes

When I take on a problem solving attitude, I feel that every effect has a cause. Such objective thinking will enable me to look at things more honestly and with less bias.

It was this problem solving attitude that enabled Louis Pasteur to make so many contributions to man's welfare.

Louis Pasteur, after thought and study decided that a disease called anthrax, which killed thousands of hogs and sheep, could be combated by vaccination. His proof, for hostile government officials, was an excellent example of the scientific method. He secured fifty sheep, vaccinated twenty-five, and then exposed all fifty to virulent anthrax germs. The vaccinated sheep lived, while the others died. In this way, Pasteur proved the value of effective thinking and reasoning. Until the early 1800's, smallpox was one of the most deadly diseases affecting mankind. Edward Jenner observed that milkmaids who had suffered cowpox never contracted smallpox. Jenner theorized that there was a connection, and proffered the idea of vaccination for smallpox. Checking his hypothesis by a scientific method with repeated testing yielded evidence that the hypothesis was correct.

Law of Cause and Effect

Nothing about us just happens. Everything takes place in accordance with natural laws. Every cause has its effect, every effect its cause.

Every change is an effect because it had a cause and all changes in the world are controlled by natural laws. But these changes are not all alike. Examples of the law of cause and effect are found in chemical and physical changes.

A farmer plows his fields or chops down trees for firewood. Water freezes into ice. Water is heated and changes to steam. Wood, a piece of steel, or a stone is sawed into pieces. In every example the form and shape of the substance is changed, but no new substances are produced, nor has anything been destroyed. Such changes are called physical changes. (Define such a change)

Soil, water, and air are changed by energy of the sun into potatoes and apples. A building burns down, and different substances such as carbon dioxide, smoke, ashes, and water are produced. Such a change is a chemical change. (Define such a change)

An example of cause and effect relationship operating in the transmission of a contagious disease.

Ten seventh grade boys decided, foolishly, to see if mononucleosis (kissing fever) was translated by osculation (kissing). Following the heritage of the courageous work on yellow fever by Walter Reed, they sat up an experiment and used themselves as guinea pigs. They were isolated for several weeks and ate only food which had been carefully sterilized. After the period of isolation, Hot Lips Betty, who had an active case of mononucleosis, agreed to kiss five of the boys and to shake hands with the other five, but not to kiss them. The ten boys were again isolated for a period of several weeks and fed sterilized food. The five who had been kissed by Hot Lips Betty developed cases of mononucleosis while the others remained healthy. If the experiment succeeded in controlling all other possible contacts with the disease causing organisms for the complete inoculation period we could assume that the law of cause and effect operated and the unhygenic kiss(cause) by Betty was responsible for the disease (effect) being transmitted to five previously healthy boys.

There is some evidence that mononucleosis is caused by a virus whose virulence is triggered by mental depression. In Rebecca Osborn's article "College Stress and Illness" (pages 22-24, Science Digest, December, 1966) researchers at Tulane University are reported to have found that all of the twelve students with monunucleosis at Tulane in the fall of 1965 were "momentarily depressed" and many were depressive prone. More wide-spread linkages have been found throughout the United States with overwhelming stress such as college freshman frequently encounter. This linkage appears to have a much closer relationship than change in locating a predisposition for the disease. Further research is needed. Where will we find volunteers?

A Misconceived Example of the Law of Cause and Effect is Found in Weather Prognostication

Weather changes are often so rapid and various that many people think that weather knows no law. It provides a beautiful day for a picnic or excursion or the reaping of a harvest, or it may spoil all these activities and do terrible damage. It may even destroy crops by drought or flood. Someone might cite the weather as an example of the unfailing work of the law of cause and effect. A rising barometer generally means fair weather, while a falling barometer usually indicates unsettled weather or rain. Does this mean that a high pressure area causes fair weather and that low pressure area causes foul weather, or does it show that two events occur as a coincidence often enough for us to expect them to share a cause and effect relationship? The statement, "the unfailing work of the law of cause and effect," should give us a clue. Under like conditions a cause will always produce its effect. Therefore, we cannot cite the coincidence of weather and a certain air pressure as being a cause and effect relationship, because if there is one instance in any year when a falling barometer is not followed by foul weather there is not always the same effect. The cause must always bring on its inevitable effect. (See drawing on following page.)

EVALUATION

1. State the law of cause and effect.
2. What are some good, everyday examples of cause and effect?
3. What is inertia?
4. What must be realized before any investigation can begin?
5. What are the steps in solving a problem?

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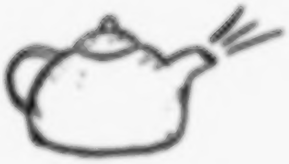
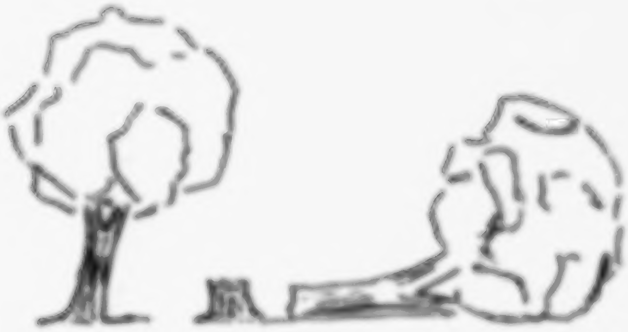
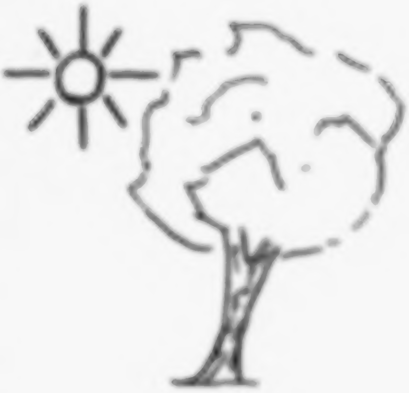
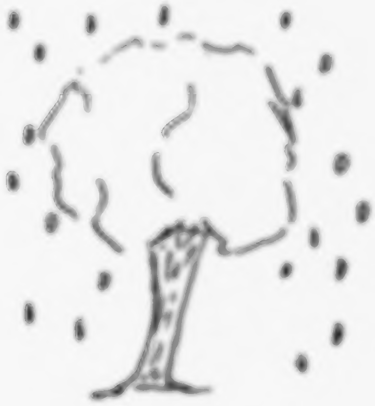
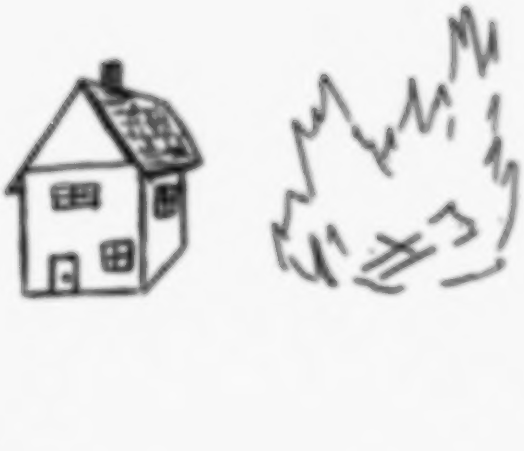
EXAMPLES OF PHYSICAL CHANGES











Objective

Show that our perception is limited.

Our Perceptions Have Limits Therefore all Knowledge Held as Tentative.

Proof of this statement.

Do you see things as they really are? Investigate and find out. For your investigation, use a piece of paper two inches wide and twenty inches long. A strip of wrapping paper will do.

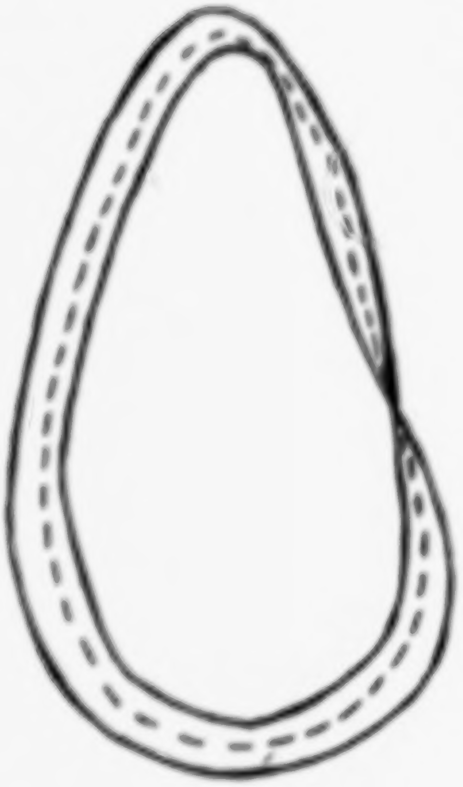
Hold one end of the strip in one hand. With your other hand give the free end a half twist. Now, bring the two ends together and fasten them with paste or transparent tape. A ribbon of paper twisted in this way is known as a Mobius strip. Does the Mobius strip have unexpected properties? Experiment and see.

Anticipatory Reflections

1. Do you see things as they really are?
2. Do you think just by looking at this Mobius strip that it has unexpected properties?
3. How many surfaces do you think the band has?
4. Do you think if we cut the strip lengthwise it will give us additional edges or surfaces?
5. What has this experiment shown us? (Things are not necessarily as we perceive them.)

Grasp the paper strip between your thumb and index finger. Move your finger along the entire piece of paper. Do you return to the starting point? On the basis of this experiment, how many surfaces does the band have? Run your finger along one edge. How many can you trace? Cut through the middle of the Mobius strip (one thickness of paper) with a pair of scissors, as shown by the dotted line. Cut lengthwise, and return to your starting point. What do you expect to get? Will you get two bands? Does the cut add another edge and another side, or surface? Cut and see. Make a second complete trip around the band with one continuous cut. What do you predict will happen?

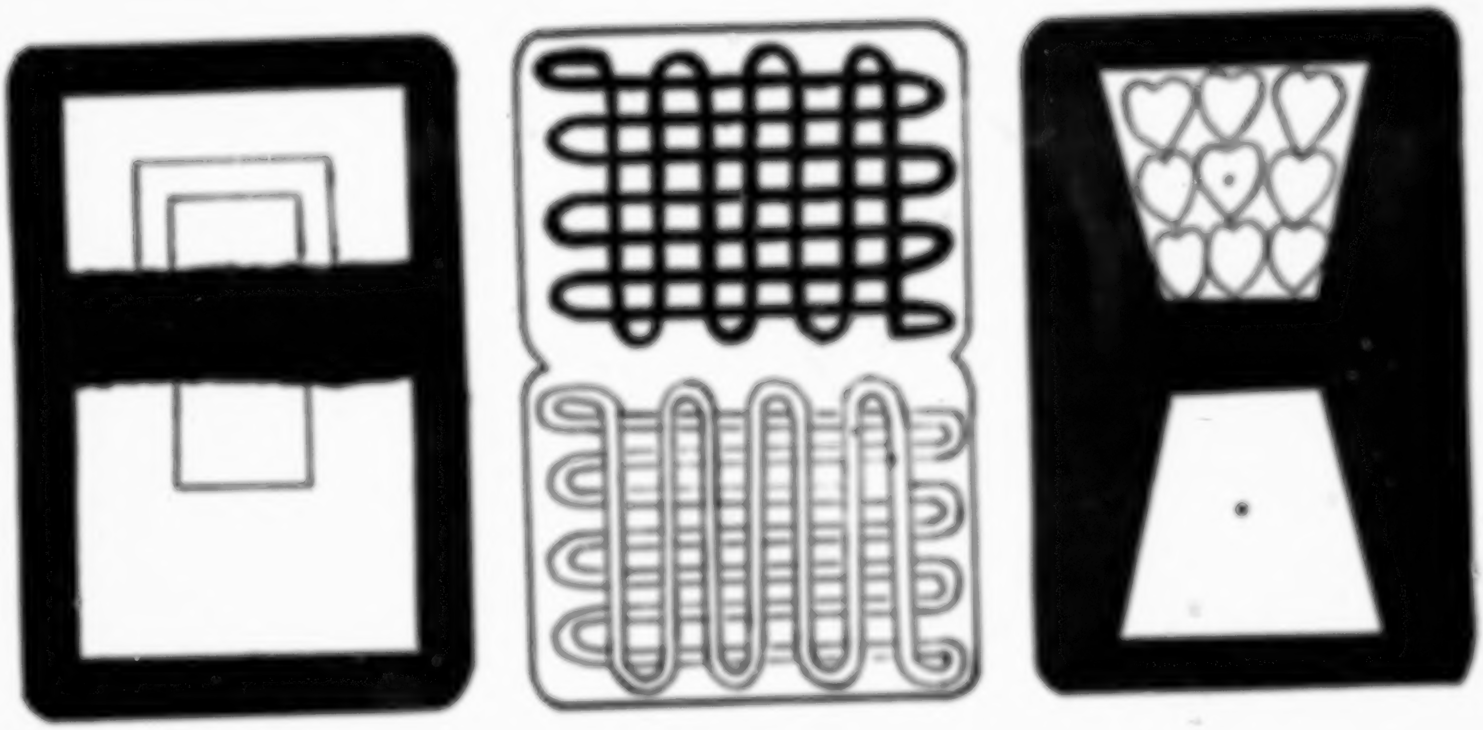
For further fun start over doing each step the same except give the paper strip a full twist instead of a half twist when you put it together. What do you predict will happen this time?



SEEING IS NOT BELIEVING IN COLOR

Activities

Have the students make posters like those below.



Reference Source

Current Science, Vol LII. No. 12, December 7, 1966.

There is more to color than meets the eye. Looking at color and seeing color are not quite the same. The tricks that colors can play on you are not magical. They have a scientific basis.

Color vision results from light energy producing chemical reactions in the retina of the eye. The particular color sent to your eye is the one reflected to it by the atoms and molecules making up a substance. Color vision depends on light, a colorant, the eye, and the brain. Color serves us in many ways. Using color is practical as well as beautiful. Man must understand color if he is to use it effectively. Chemists and physicists in industrial research laboratories study color behavior and theory. Color technology is used in graphic arts, textiles, plastics, lighting effects, advertising, and decorations. The above demonstrations in color perception should be instructive as well as entertaining. What should you have learned from the above surprises in color?

Fig. A - Compare the two light blue areas above. Describe their individual appearance. They are printed with the same colored ink. Why do they appear different;

Answer - Background colors affect foreground colors.

Fig. B - Place a pencil between the black and white grills. Compare the red background behind the two grills. What difference do you observe? What causes this effect?

Answer - The human eye tries to integrate different colors seen at the same time into a single hue.

Fig. C - Stare at the black dot in the green heart for 30 seconds. Then look at the black dot on the white screen. Describe what you see and explain.

Answer - Afterimages caused by prolonged staring at one color can appear in complementary colors. So, be cautious when using colors.

Scientific Results Must be Repeatable

The process typical of scientific research is a scientific method. Regardless of topic or field of investigation, there are certain procedures of an orderly critical method of study that are likely to bring reliable results.

Before any investigation can begin, there must be a realization of a problem.

The starting point for a scientific approach to a study is a clear-cut statement of a problem. It is important that the problem chosen should be rather simple and narrow in range.

Once a problem has been selected, the investigator will want to survey all of the scientific literature available that might have a bearing on it. He needs to know what others have discovered about the problem in order that he may properly plan his work. He may locate suggestions as to techniques of procedure which will be very valuable.

After a survey of the literature, the investigator may be in a position to make a hypothesis, which might be described as an "educated guess." On the basis of previous findings, he formulates what appears to be the most likely explanations. To arrive at a definitive solution of a problem he needs a hypothesis which can be tested for validity. In many scientific investigations it is possible to control the subjects under investigation and to conduct experiments on them. In the experiment all conditions are controlled except one. The investigator then can reach a conclusion.

Two Scientific Methods showing why scientific results must be repeatable:

1. According to legend, Galileo (1564-1642) and his assistant tested the hypothesis that heavy objects fall at a faster rate than a light object. Galileo and his assistant climbed the leaning Tower of Piza and dropped two balls, one heavy and the other light. They demonstrated that objects fall at the same rate of speed regardless of weight.

Each time we perform this experiment in class we get many different hypothesis given by the students as to why certain things happen before and after the experiment. Many students will question the conclusion after completing the experiment.

From this experiment we consider three aspects of Galileo's theory:

A. The law of falling bodies,

B. The principle of inertia,

C. And the composition of independent motions.

2. Understanding inertia (The results of this demonstration should be repeatable)

First teach the definition for inertia which is, "The property of matter that resists changes in its state of rest or motion."

Activity-Inertia Teaser

The Gun Kick Back

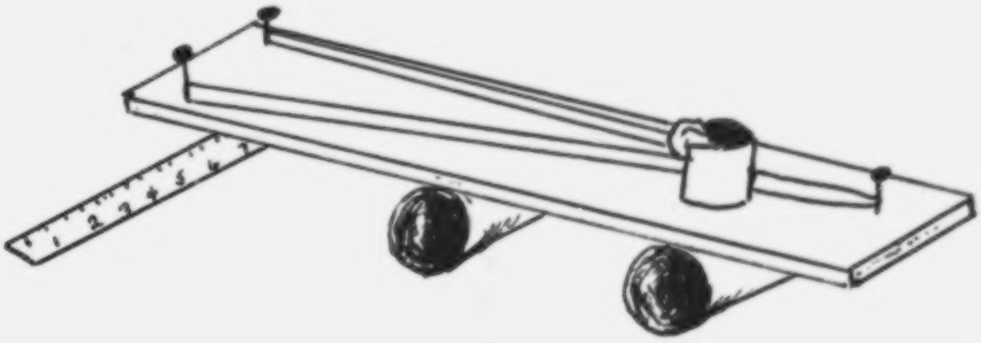
This experiment will help students understand that when a bullet is fired from a gun, the gun itself always kicks back. In the same way, a rocket is driven forward by the "kick" given to it by gas shooting out of its jets. Students should understand that for every action there is a reaction. They cannot start anything moving without setting something else moving in the opposite direction if both objects are equally movable. "To every action there is an equal and opposite reaction."

In shooting the gun, the action is the forward motion of the bullet. The reaction is the backward kick of the gun.

To show action and reaction which will vary in each trial or test, make a rubberband gun mounted on a block or cart that can move freely. Drive three nails into a length of board. Cut open a heavy rubberband and wrap the ends around the two nails that are side by side. Tie the ends securely with string. Pull the rubberband with a loop of string that goes over the third nail. Use a small rock as the bullet.

Place the board on two juice-can rollers and set a marker on the floor alongside the front end of the board. Fire the gun without touching the set up by burning the loop of string with a match. The rock shoots forward and the block or gun cart moves backward at the same time.

The rock and cart both now have the inertia of motion. Like all objects exposed to gravity which pulls them down with the friction of air to slow them down, the rock and the cart lose the inertia of motion which unchecked would keep them moving apart forever. Children will like this experiment, especially the boys. They continue to try it and form many different hypothesis.



Scientific results must be repeated to establish that they are dependable if conditions are the same.

Test the reliability of your findings by repeating the gun cart experiment under conditions as exactly alike as possible. Are the results the same? What factors are not completely the same? Do you suppose that equipment and measurement contribute to varying answers for scientists?

Examples of the Scientific Method

Was yellow fever spread through contact with clothes of people having disease?

Three doctors, Lazear, Reed, and Carroll, of the United States Army, suspected that a certain kind of mosquito spread this disease by biting people. It was the common belief that yellow fever was spread through contact with clothes of persons having the disease. These doctors stated the problem to themselves something like this:

Problem: Is yellow fever carried by insects (mosquitoes) or by clothing of people who have the disease?

These three physicians next set to work to find the answer to the question.

What materials were to be used?

Materials: Two doctors, a screened building, clothing and bedding of two persons who had died of yellow fever. Now what did they do with these materials? How did they use them to bring about a natural result?

Method: They placed the doctors in the screened building where no mosquitoes could reach them, but had them wear the garments and sleep in the bedding of the persons who had died of yellow fever.

What happened as a natural result?

Observation: Nothing happened. The doctors did not get sick. These doctors wanted to be sure, however, so they tried the same thing with other well persons, but with the result.

What did they conclude?

Conclusion: Yellow fever is not carried by clothing. Something else carried the disease.

Of what good was this conclusion?

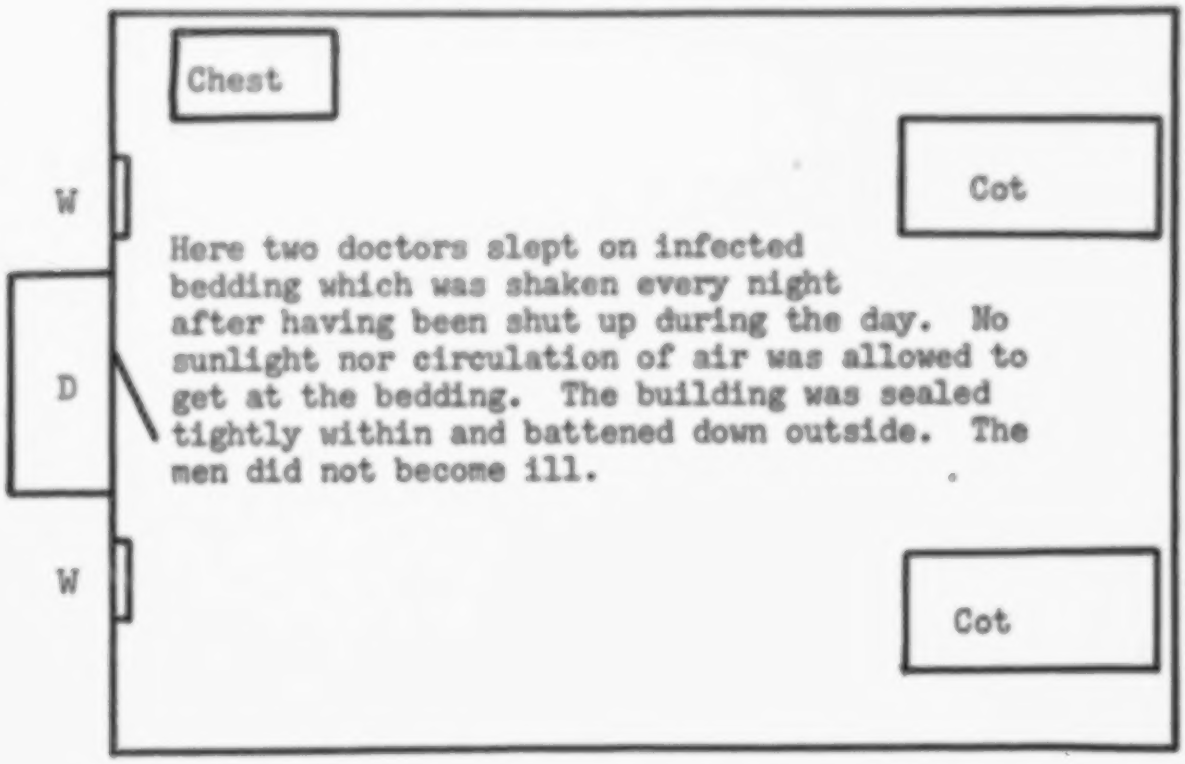
Practical Application: People do not need to fear to come in contact with the clothing or bedding of people suffering from yellow fever.

(This may be followed through by describing the yellow fever exposure experiment, if desired.)

What causes yellow fever? (one scientific method of study)

The following diagram based on official report of doctors' study made at Camp Lazear.

Infected-Bedding Building



Here two doctors slept on infected bedding which was shaken every night after having been shut up during the day. No sunlight nor circulation of air was allowed to get at the bedding. The building was sealed tightly within and battened down outside. The men did not become ill.

D - Screen door W - Screen window

STEPS IN THE SCIENTIFIC METHOD: NUMBER 1

1. Statement of problem: To determine what caused a rash in three members of a six member family.

2. Collection of facts: To record all contacts of each family member with items new to them in the past week.

3. Formation of a hypothesis: The new object common to all cases of rash is the cause of the rash.

4. Deduction of further facts: The objects not in contact with all people with rash did not cause the rash.

5. Verification of the deducted facts: The object not in contact with the member without rash but in contact with all persons with rash is the cause of the rash.

Example of deduction: All below mentioned members of a family developed a rash.

Method of Agreement: Often the physician may use this method for preliminary treatment of patient.

Phenomena of Rash	Berries	Skin Lotion	Soap	Fruit Juice
Father	x	x	x	x
Mother		x	x	
Dick			x	x

x - Stands for a contact with the object.

STEPS IN THE SCIENTIFIC METHOD: NUMBER 2

Method of Difference

Instance of Rash	Berries	Skin Lotion	Soap	Fruit Juice
Father	x	x	x	x
No Instance of Rash				
Bob	x	x		x

The example above shows clearly that the rash was caused by soap.

STEPS IN THE SCIENTIFIC METHOD: NUMBER 3

Let us verify by the joint method of agreement and difference.

Instance of Rash	Berries	Skin Lotion	Soap	Fruit Juice
Father	x	x	x	x
Mother		x	x	
Dick			x	x
No Instance of Rash				
Bob	x	x		x
Ruth	x	x		
Beth		x		x

The above method is one set aside by John Stuart Mill in the 19th century.

It is a way of (or criteria for) evaluating an hypothesis. If no new facts can be deducted from the hypothesis then an invariant connection with the effect is supposed to explain and perhaps be able to check this deduction.

EXAMPLES OF APPLYING SCIENTIFIC METHOD

Define the Problem

A new outfit is wanted for a special occasion. The problem is how to go about getting it.

Study Known Facts, Also Consider Prior Observations

From previous experience (of brothers, sisters, or self) it is known that just asking for it will not accomplish the desired results. The allowance will not cover it. Occasionally a trade or compromise has worked.

Draw a Tentative Conclusion or Hypothesis.

Remembering this is the season of falling leaves, it is felt that possibly volunteering to rake some leaves, pile them, burn them, and do a good job on the yard, might cause the new outfit to be considered a good reward.

Putting the Hypothesis to the Test.

Parents are approached with the problem and the solution. Parents may suggest an additional chore to more evenly balance the amount of work versus the amount of the outfit will cost.

Form A Conclusion.

Providing the parents have the money, the conclusion is acquiring the outfit. If they don't have it even the fair offer of working it out may not be considered. In this case, the person would have to find outside work to earn the money for the outfit.

Note: The job can be changed with the seasons - shovel snow, mow the lawn, plant the garden, etc.

Another Example:

John has an allowance of $1.50 per week to spend as he sees fit. The scientific method of reasoning how to spend his money could well be applied to the problem of wise spending. If he spends it all in one day, he has nothing for the other six days. If he thinks and studies the possible ways of spending his money wisely, he has applied a scientific method of reasoning to something which is far from the field of science. So is learning applied.

SCIENTIFIC METHOD IN EVERY DAY LIVING

Problem or Question

Is better food sold at more reasonable prices at small stores or large supermarkets?

Observation and Analysis

Eight students go to both kinds of stores. Four students go to four small stores and four go to four different large stores. They write down information on the net weight and price of various types of canned goods. They return and analyze the data they obtained to find the price per unit of weight for each kind of canned food in each of the eight stores (4 large and 4 small).

Generalization

They made generalizations about the foods and prices relating to them from their findings. They may theorize about their findings. When we give the best reason we can find for anything, and yet cannot really prove that the reason is the right one, we are offering a theory. An example might be like the statement that larger stores have lower prices than small stores.

They still lack enough observed samples so they return to the original problem. They go to other stores and repeat the observation and analysis process. With further observations they may be able to make a final generalization about the cost of various canned goods at large and small stores.

Verification

Their findings may be verified by more extensive observations.

Conclusion of the Problem

They can arrive at a conclusion, and the knowledge gained may be used in everyday purchases. This is called application.

Man frequently uses all these steps and more in his daily life when he buys food, clothing, hardware, cars, and many other things. Man uses scientific methods more often than he realizes.

EVALUATION

Present several open-end problems to the class. Ask them to select one that interests them and have them review the literature and form at least one trial hypothesis. Ask them to further set up experiments to test the hypothesis.

What further steps would be needed to establish the results as scientific fact?

References

Navarra, John, Joseph Zaffaroni, John Garone. Today's Basic Science. New York: Harper and Row, 1965.

CHAPTER II

NERVOUS SYSTEM

Objectives

1. What are the functions of our nervous system?
2. How does my nervous system relate to my physical body?
3. What are the interactions of my body and my nervous system with my active thinking processes?
4. How do we receive and respond to information?

What are the main parts of the nervous system?

A. The Central Nervous System which consists of:

   1. the brain and
   2. the spinal cord;

B. The Peripheral Nervous System - which consists of nerves to the various -

   1. organs and,
   2. tissues;
   3. the peripheral nerves are concerned mainly with the conduction of nerve impulses to and from the central nervous system and consist of the spinal nerves and the cranial nerves.

C. The Autonomic System - which includes -

   1. ganglia or groups of nerve cells located in different parts of the body exercising control of the -

      a. viscera, and
      b. blood vessels;
      c. the autonomic nervous system (so called because it is self-acting) is a built-in control; it acts upon smooth muscles and glands, and it services structural parts such as the alimentary canal, lungs, heart, glands, and urinary bladder, and keeps them functioning properly. If it were not for the autonomic nervous system, life would become impossibly complicated, because each body function would have to be consciously thought about before

it was performed. This system acts in general at a level below that of consciousness and will power. The autonomic nervous system is composed of two parts called:

(1.) the Sympathetic ganglia, four nerves of which serve to speed-up certain body organ activities; and in opposition the

(2.) Parasympathetic ganglia, four nerves of which tend to relax muscles in certain organs.

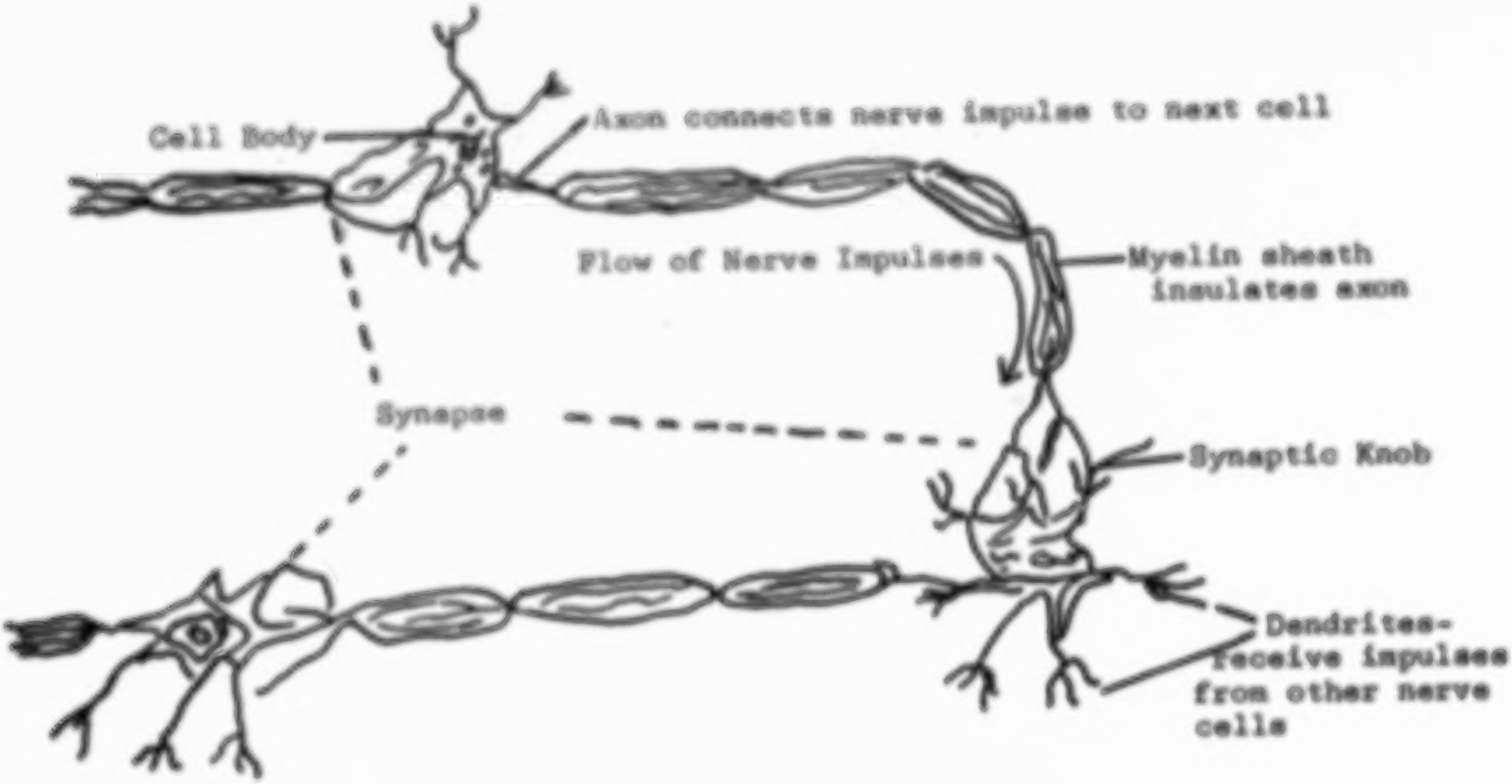
These two divisions of the autonomic system work together and balance each other in stimulating and inhibiting the activity of the organs of the body. If a sympathetic nerve stimulates an organ, the corresponding parasympathetic nerve will inhibit it.

Man's ability to keep in contact with the outer world is due largely to his nervous system. The human body is so complex an organism that it requires a very complex nervous for its direction and control.

You see, hear, and feel with your nervous system. It helps you keep out of danger and protects you from serious harm. It also helps you to learn and to remember.

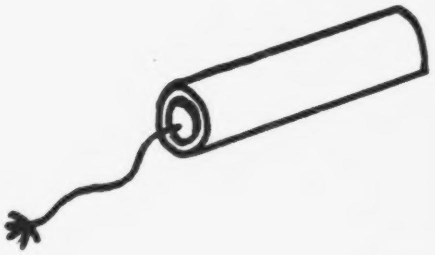
The nervous system can be looked upon as a vast communications network. There are thousands of nerve cells in the system. These cells are known as neurons. If the neurons were placed end to end, they would encircle the earth several times. The neurons are grouped together to form nerves, which are the lines of communications. The nerves lead into the brain and spinal cord.

The basic unit of structure and function of the nervous system is the nerve cell or neuron. It consists of a cell body, containing a nucleus, and a number of tree-like branches of protophasmic material called dendrites. They carry nerve impulses toward the cell body. The long, thin branch of cytoplasm, called the axon, carries impulses away from the cell body, and may be extended several feet away. Impulses brought to the cell by dendrites are transmitted over the axon to the next neuron in a chain of neurons, or may discharge the impulse into a gland or muscle. Neurons do not make contact with other neurons; there is always a small gap between the nerve cells. The end brushes of one axon lie near the end brushes of the dendrites of the next neuron, and this point of contact is called the synapse. (See diagram)


Cell Body
Axon connects nerve impulse to next cell
Flow of Nerve Impulses
Myelin sheath
insulates axon
Synapse
Synaptic Knob
Dendrites-
receive impulses
from other nerve
cells

There are three kinds of neurons: sensory neurons, motor neurons, and association neurons. A sensory neuron is a nerve cell that transmits messages to the brain or spinal cord. A motor neuron carries messages from the brain or spinal cord to muscles, glands, or organs. The association neuron connects a sensory neuron with a motor neuron; it may serve as a connection between other association neurons.

The impulse that runs along to stimulate nerve fiber is somewhat like the burning of a firecracker fuse. Before the action, both the fuse and fiber contain potential energy. The burning of the fuse and the passage of the nerve impulse release the stored energy. In both, the change at one point starts the change at the next point. When the reaction reaches the end of a fuse, the firecracker explodes. At the end of a nerve fiber, a gland may begin to secrete, a group of muscle fibers may contract, or an impulse may start in another nerve fiber. (See diagram)



The Nerve Impulse May Be Compared to a Spark
Traveling Along a Fuse

Two important properties of the nerve impulse are analogous to what occurs when a fuse is lighted.

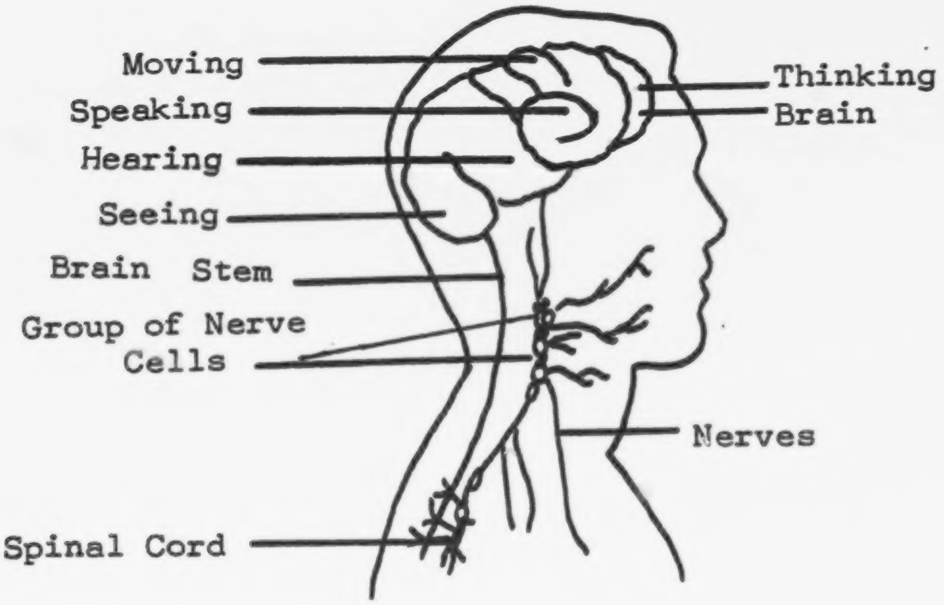
1. As long as the nerve cell is stimulated by an impulse of a certain minimum strength, it makes no difference how strong the exciting impulse is; just as a match or a blowtorch produces the same reaction in a fuse. This is known as the all-or-none-law.

2. The nerve impulse remains at the same strength as it travels along the nerve fiber, just as the spark remains at the same intensity as it moves along the fuse.

The neurons serve as signal carriers for the brain and the spinal cord. The brain and spinal cord are, of course, important parts of the nervous system. In fact, they are the central control points of the whole network.

Strictly speaking, the brain and the spinal cord make up the *central nervous system*. The neurons are linked into a subdivision known as the *peripheral nervous system*. The peripheral nervous system consists of thirty-one pairs of spinal nerves and twelve pairs of cranial nerves.

Diagram Showing Parts of the Nervous System and Some Control Centers in the Brain


Moving
Speaking
Hearing
Seeing
Brain Stem
Group of Nerve Cells
Spinal Cord
Thinking
Brain
Nerves

If your finger touches a hot stove or is stuck by a pin, your arm is automatically jerked away. This kind of automatic response is called a reflex action, or "reflex" for short. When the hot stove is touched or the pin stuck in, tiny sense organs in the finger receive a stimulus. They start impulses traveling along the fibers of some sensory neurons. These carry the impulses up the arm and into the spinal cord. There they start impulses in association neurons. These in turn carry impulses to certain motor neurons, which send impulses to various arm muscles. When the impulses reach the muscles, your arm is pulled back. All the connections for reflex actions have been made. The impulses always follow the same paths. So the responses are always the same.

FACT SHEET FOR THE CENTRAL NERVOUS SYSTEM

The central nervous system consists of the Brain and the Spinal Cord. The brain will be discussed first.

A. Brain: There are three main divisions of the brain

1. Cerebrum
2. Cerebellum
3. Medulla

1. Cerebrum - The cerebrum is the largest division of the brain. It is divided into two halves called hemispheres.

Controls: The voluntary, conscious activities of the body. It is the center for the control of all.

a. Conscious muscular actions
b. Thinking
c. Interpretation of all impulses from the sense organs

Makeup of Cerebrum -

a. Outer layer - called the cortex
b. Each hemisphere is divided into lobes.

Cortex - enables men to think, reason, invent, and plan. It is the center of intelligence and judgment, which makes it possible to add to the store of knowledge and profit from past experience.

2. Cerebellum - The cerebellum is a much smaller area of the brain than the cerebrum, located in lower rear region of the skull.

Controls: Reflexes of the skeletal muscles of the body
Functions appear to be below the level of consciousness and have a part in maintaining balance and body equilibrium

3. Medulla - The medulla is the lower part of the brain that connects with the spinal cord.

Controls - Those actions over which we have little or no conscious influence. Contains the centers for the regulation of respiratory, cardia, and various other involuntary reactions. These centers are associated with breathing, digestions, circulation, and the secretion of some glands. It also regulates coughing, sneezing, and swallowing.

B. Spinal Cord: The spinal cord lies within the backbone, it is a center for spinal reflexes.

Composition: The outer layer of the cord is white matter and the inner part is composed of gray matter.

Gray matter - contains the cell bodies of motor and association neurons.

White matter - has both ascending tracts, which carry impulses to the brain to the muscles and glands.

All the cranial nerves are connected directly to the brain. Impulses traveling through these nerves by-pass the spinal. Some cranial nerves contain both sensory neurons and motor neurons. Others contain only sensory neurons or only motor neurons. It is the sensory neurons that carry messages to the brain. The brain's instructions then go to another part of the body via the motor neurons.

The energy transmitted by any nerve goes to a specific place in the spinal cord or brain. Each receptor has a part of the brain to which its impulses travel. It is the specific part of the brain that gives a sensation its particular nature, not the specific receptor.

Man's Nervous System

The non-skeletal muscles and the glands are controlled by special nerves and certain parts of the brain and spinal cord. These muscles and glands are response organs that help the body carry on such regular activities as digesting food, circulating blood, and breathing. The parts of the nervous system which control these activities are classed as the autonomic nervous system.

The autonomic nervous system has its own motor nerves and many of its own sensory nerves; it also has its own reflex centers in the brain stem. Impulses go from sense organs or parts of the central nervous system to centers in the autonomic nervous system. From these centers, impulses are sent to response organs, including the muscles in the heart, the esophagus, the arteries. The salivary glands, the gastric glands, the sweat glands, and the tear glands.

Even though the autonomic nervous system is largely independent of the rest of the nervous system, it is not entirely separate. Certain parts of the brain send impulses to the autonomic nervous system either directly or indirectly.

As we have learned, the brain and spinal cord are called the central nervous system. All behavior is controlled directly or indirectly by a part of the brain or spinal cord. The spinal cord plays an important part in many reflex actions. Much of it is made up of association neurons through which impulses travel to produce reflexes. From these reflex centers in the spinal cord, motor nerves lead to all skeletal muscles in the arms and legs and most of the trunk of the body.

The spinal cord also forms a great highway for impulses traveling between the brain and the parts of the body below the neck. The bundles of neuron fibers that carry impulses to and from the brain make up over half of the spinal cord. If the fibers were cut, a person would lose all feeling in the parts of the body from which they come. He would also lose all control of the muscles to which they lead. Even though there is nothing wrong with his sense organs, muscles, and brain, he would be paralyzed. So the spinal cord is important for two reasons: (1) It contains the association neurons for many reflexes. (2) It carries impulses between the brain and the other parts of the body.

One of the main parts of the brain, the brain stem, extends upward from the spinal cord but is thicker than the spinal cord. It is called the medulla. The brain stem does the same kinds of things as the spinal cord. Like the spinal cord it contains the association neurons for certain reflexes. In it are the centers for reflexes that help a person to swallow and breathe; it regulates the size of the arteries and the rate of the heartbeat. Other reflex centers in the brain stem regulate the temperature of the body. Impulses from these centers go to the sweat glands, the muscles, and the blood vessels in the skin.

Centers in the brain stem also play an important part in influencing emotions and the responses to them. The brain stem has many bundles of neuron fibers that carry impulses between the spinal cord and upper parts of the brain. Several pairs of important nerves from the chest, the throat, and the face connect with the brain stem.

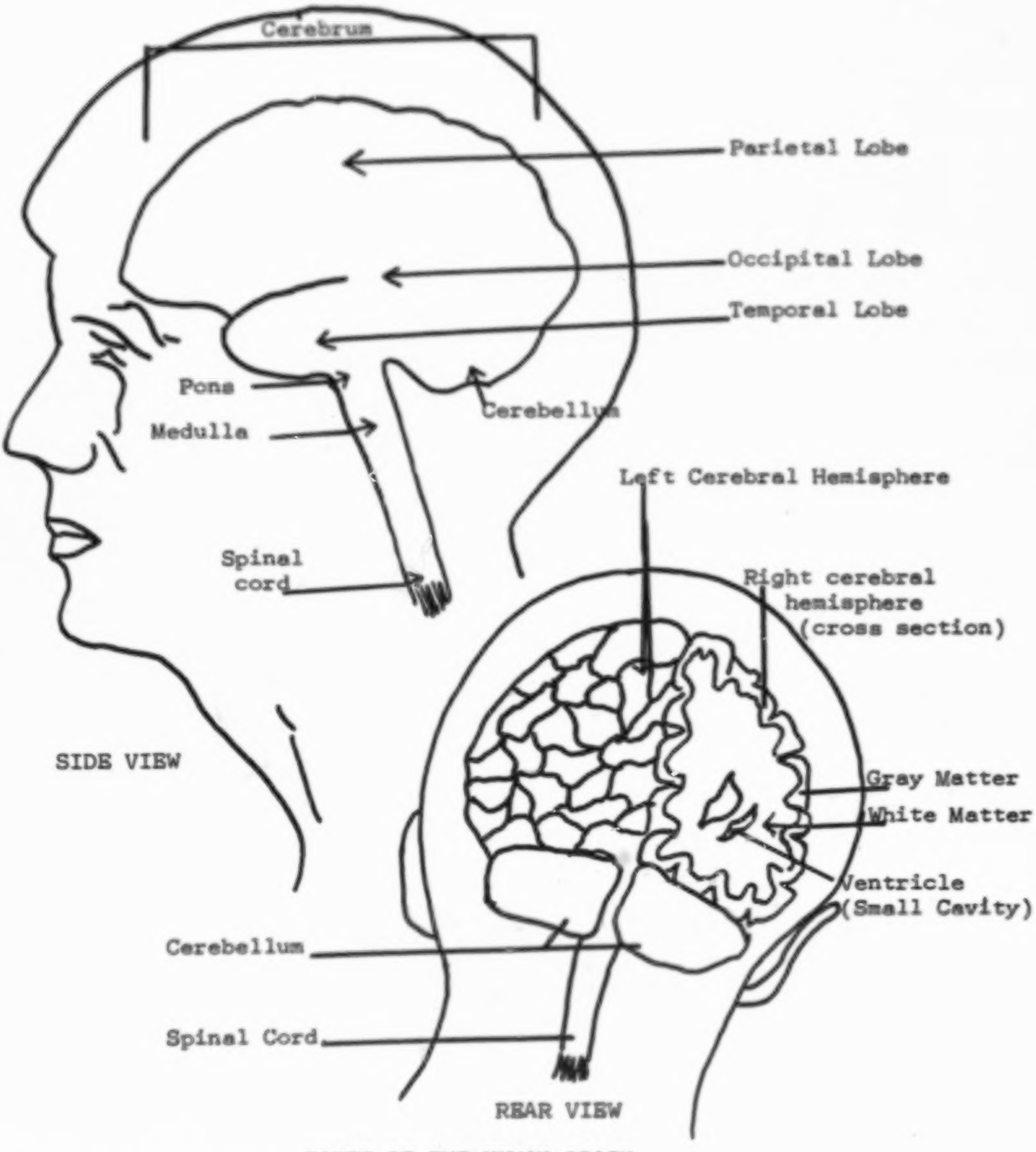
Attached to the brain stem and lying behind it is the cerebellum. Scientists believe that the main work of this part of the brain is to regulate movements of the skeletal muscles. The cerebellum acts as a kind of switchboard and automatic times which directs the routing and timing of impulses going to the muscles, causing them to contract and relax in just the right order and in just the right amount. When a leg or arm is moved, a person does not have to think about how to regulate the muscles involved; the cerebellum, probably helped by reflex centers in the brain stem, does this. It automatically regulates all the skeletal muscles. If the cerebellum is injured, a person cannot move his arms and legs smoothly and accurately.

By far the largest part of the human brain is the cerebrum. This is also attached to the brain stem, bulging over it and the cerebellum. Only one part of the brain---the cerebrum---enables a person to remember, learn, plan, and do other thinking. The cerebrum is much more highly developed in humans than in any other vertabrates. All of the most closely related to what we call the "mind." The relation between the brain and the "mind" is one of the deepest mysteries of science.

Psychologists have mapped out three large areas of the cerebrum and know something of what each area does. The sensory area is made up of sensory centers for sight, hearing, smelling, tasting, and other sensory impressions. Sensory nerves from each sense go to this center. The motor area is made up of motor centers, with motor nerves leading from these centers to different groups of skeletal muscles. The most mysterious part of the cerebrum is sometimes called the association area. This part seems to be required for a person to be aware of the meanings of things and to remember things that have happened in the past. The sensory area, the motor area, and the association area are connected together by fibers of association neurons, so impulses can travel from centers in one area to those in the others.

Any willful-conscious, response is said to be a voluntary response. Any response that does not depend *directly on will is* said to be an involuntary response. Involuntary responses of the skeletal muscles are reflexes. The responses of the other muscles and the glands are all involuntary. Centers outside the cerebrum direct involuntary responses which take place automatically whenever certain stimuli are received.

Reflexes help you to automatically respond in many ways. They quickly pull part of your body away from something hot or sharp, they make the pupils of your eyes get larger or smaller, regulate the rate of your heartbeat and the contraction of your stomach muscles, as well as causing coughing and sneezing. Reflexes not only help protect you from harm they also help control your reguler activities such as blood circulation and food digestion. In a reflex, impulses travel directly and automatically from a sense organ to a center in the brain or spinal cord, and then from the center to a response organ.


Cerebrum
Parietal Lobe
Occipital Lobe
Temporal Lobe
Pons
Medulla
Cerebellum
Spinal cord
SIDE VIEW
Left Cerebral Hemisphere
Right cerebral hemisphere (cross section)
Gray Matter
White Matter
Ventricle (Small Cavity)
Cerebellum
Spinal Cord
REAR VIEW

PARTS OF THE HUMAN BRAIN

Today's Basic Science. Navarra, Zafforoni, Garone. Harper & Row, Page 25.

MAN'S SENSES AND THEIR LIMITATIONS

Objectives

1. What are our senses and how are they used?
2. What are the limits of our senses?
3. How can we extend the range of our senses?

All vertebrates and most other complex animals have sense organs that receive stimuli. The eyes are sensitive to the stimulus of light, while the ears are sensitive to the stimulus of sound. In the nose are the sense organs of smell which are stimulated by the chemicals in the form of gases or vapors. These pass through the air, go into the nose, and touch the sense organs. The sense of taste depends partly on taste buds in the mouth, which are sense organs, too. There are four kinds of taste buds; each kind is sensitive to just one taste; sweet, sour, bitter, or salty. Taste also depends partly on the sense of smell.

There are many other sense organs all over the body. Often, these are just free nerve endings. In skin, alone, there are several million of these sense organs. They are sensitive to the stimuli of heat, cold and pressure. Still other sense organs are deeper inside the body in muscles, tendons, intestines, and even the walls of the blood vessels. All the sense organs give an animal information about what is happening in its surroundings or in its body. Each type of sense organ is especially sensitive to a certain kind of stimulus. The sense organ is connected with the spinal cord of the brain by a sensory nerve. When these sense organs receive the proper kind of stimulus, impulses start traveling along this nerve.

How Am I Aware of My Surroundings?

The main way that I know I am surrounded by a world of things and people different from myself is by the senses of:

1. Sight
2. Sound
3. Taste
4. Touch
5. Smell

If I possess none of these traits then I am not aware of my surroundings. To simplify a task of explaining my awareness I can simply show the function performed by each sense, and perhaps prove that the more senses working for me the more aware I am of my surroundings.

What Gave Rise to My Being Aware by the Above Special Senses?

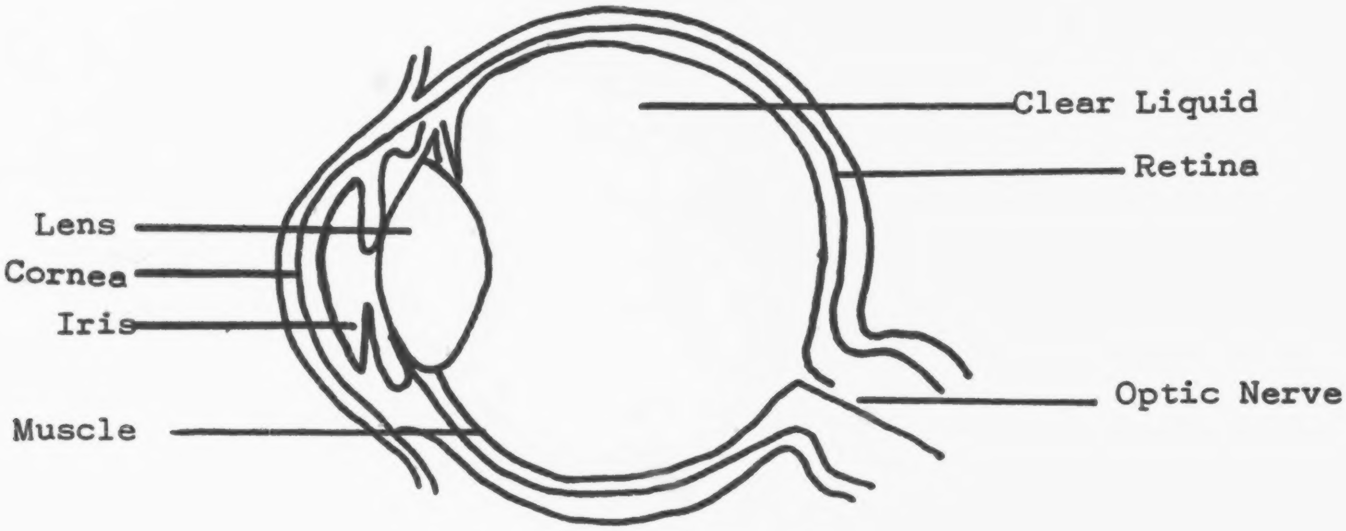
I have specialized cells or nerve cells which are connected with the central nervous system. The nerve cells extend to all parts of the body where they are able to pick up feeble impulses from the eye, ear, tongue, nose, skin surface, or all internal parts of the body.

These nerves send messages of heat, cold, pain, sound, taste, smell and other sensations to the brain where they are relayed back to the point of contact with something we call a stimulus.

A stimulus is the name given to something in our internal or external environment that causes our special senses to become aware of their presence. Examples are a grain of salt, a cold wind, a bright light. These are thus, becoming aware of things around us.

Receptors pick up nerve impulses from all parts of the body and carry them to the brain to be analyzed. When the brain returns the impulse we become aware of the presence of something in our environment.

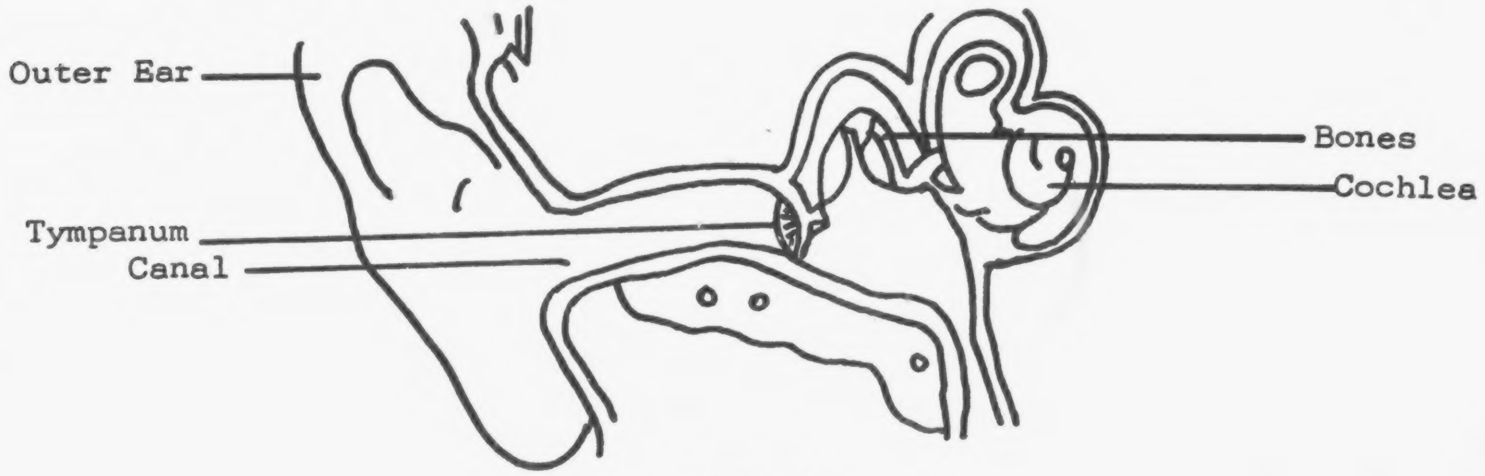
Sight is the way man uses light to aid him in his environment. A person without sight has great difficulty in adjusting to his environment. The eye is able to use the reflected light to make the environment a pleasant place to live. The optic nerve picks up light rays from the retina and converts them into uniform patterns or images, thus, it is the light from objects in man's environment that enables him to judge distance and handle effectively all things in his environment.



THE EYE

The ear, centered deep in the skull, is a sense organ in man that has two functions: (1) it is the receptor of sounds coming from the external and internal environment of man, and (2) it controls man's balance and orientation with respect to other objects on earth. We call this equilibrium.

The ear is composed of the outer ear, the middle ear, and the inner ear. It transmits sound mainly from the outside to the deep lying sensory cells. The ear makes man aware of the manifold things around him which make sounds and man becomes farther aware of his external environment or surroundings.



THE EAR

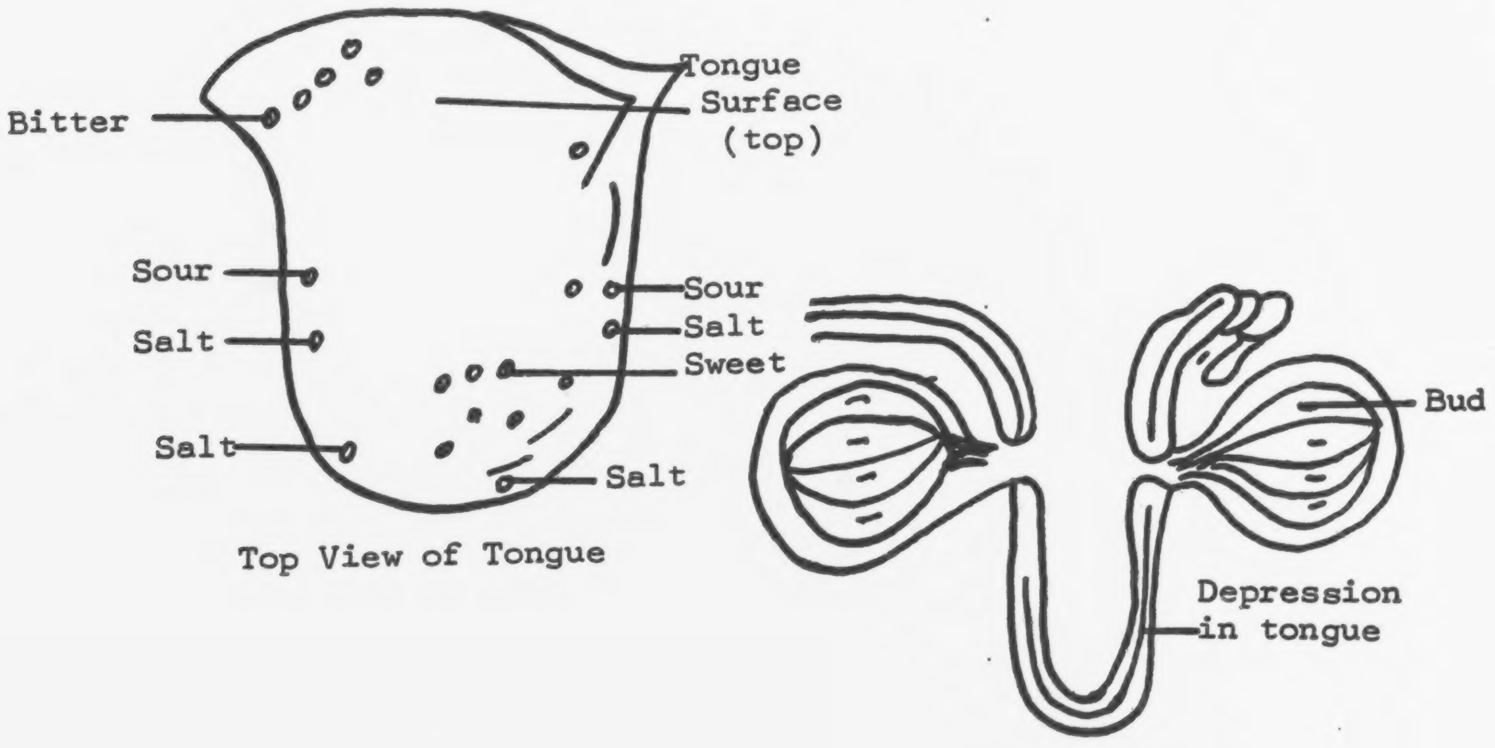
Taste Sense --

The sense of taste and smell are intricately linked with man's obtaining food. The taste and smell senses are activited by certain chemical substances and are often referred to as the "chemical senses." The tongue, tied to the floor of the mouth, is the principle organ of taste. Over 2/3 of the tongue is covered with tiny "taste receptors," which respond to things that come in contact with them.

The middle-top portion of the tongue's surface is insensitive to all tastes. Our greatest sensitivity to a sweet taste is located at the tongue's tip. A sour taste is detected best at the sides of the tongue, bitter at the back while a salt taste is registered relatively evenly around the edges of the tongue. Although sensitivity varies for these tastes according to the area involved, electrophysiological records, in the form of oscillographic tracings, from individual receptor cells or their associated single sensory nerve often show mixed sensitivity. Therefore, we can reject the hypothesis that separate taste buds are involved in the tastes just discussed.

Taste is a complex sense dependent the chemical, tactile, warm and cold receptors in the mouth as well as the smell receptors in the nose. Both taste and the degree of taste discrimination are reduced if the sense of smell is inhibited or reduced as demonstrated when a person has a head cold.

The Tongue and Gustatory Pores



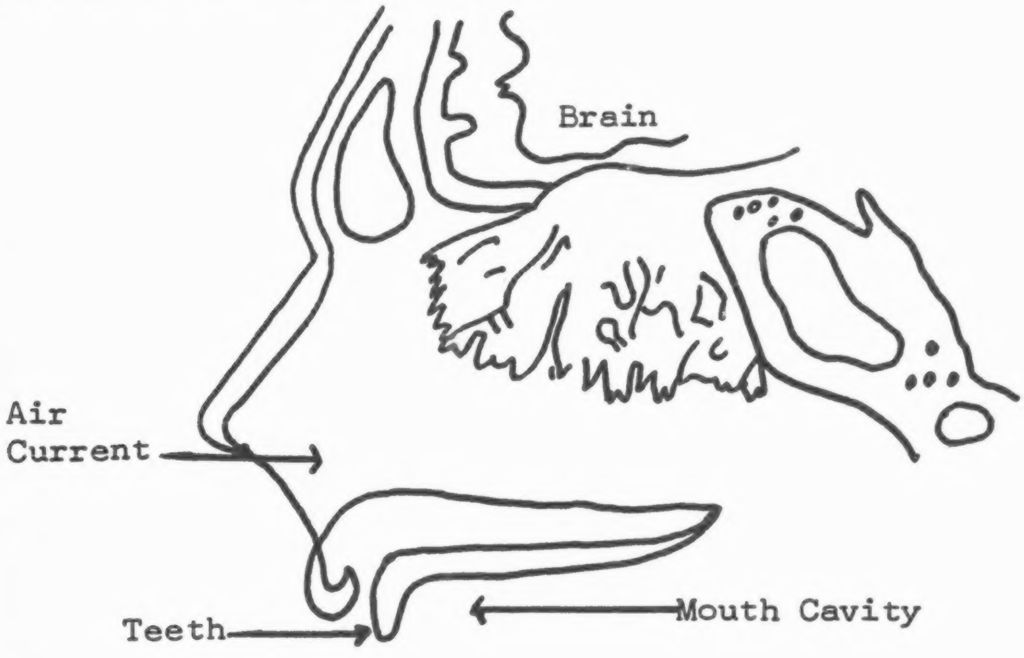
Top View of Tongue

Taste Buds

A diagram of half of the human tongue illustrating areas of maximum sensibility of the four primary taste qualities.

The olfactory nerves are located at the base of the eyes and at the roof of the mouth where they pick up the various odors and transmit them to the brain. In this way certain odors can be determined by the individual in his environment.

Detection of odors can be important to man for warning of a possible need for attention and for identification. He may become aware of fire long before he sees the flames. There are many other ways that the sense of smell makes him aware of safe or dangerous surroundings. As we have learned, odors are also important contributors to what we call "taste."



Branches of the Olfactory Nerve

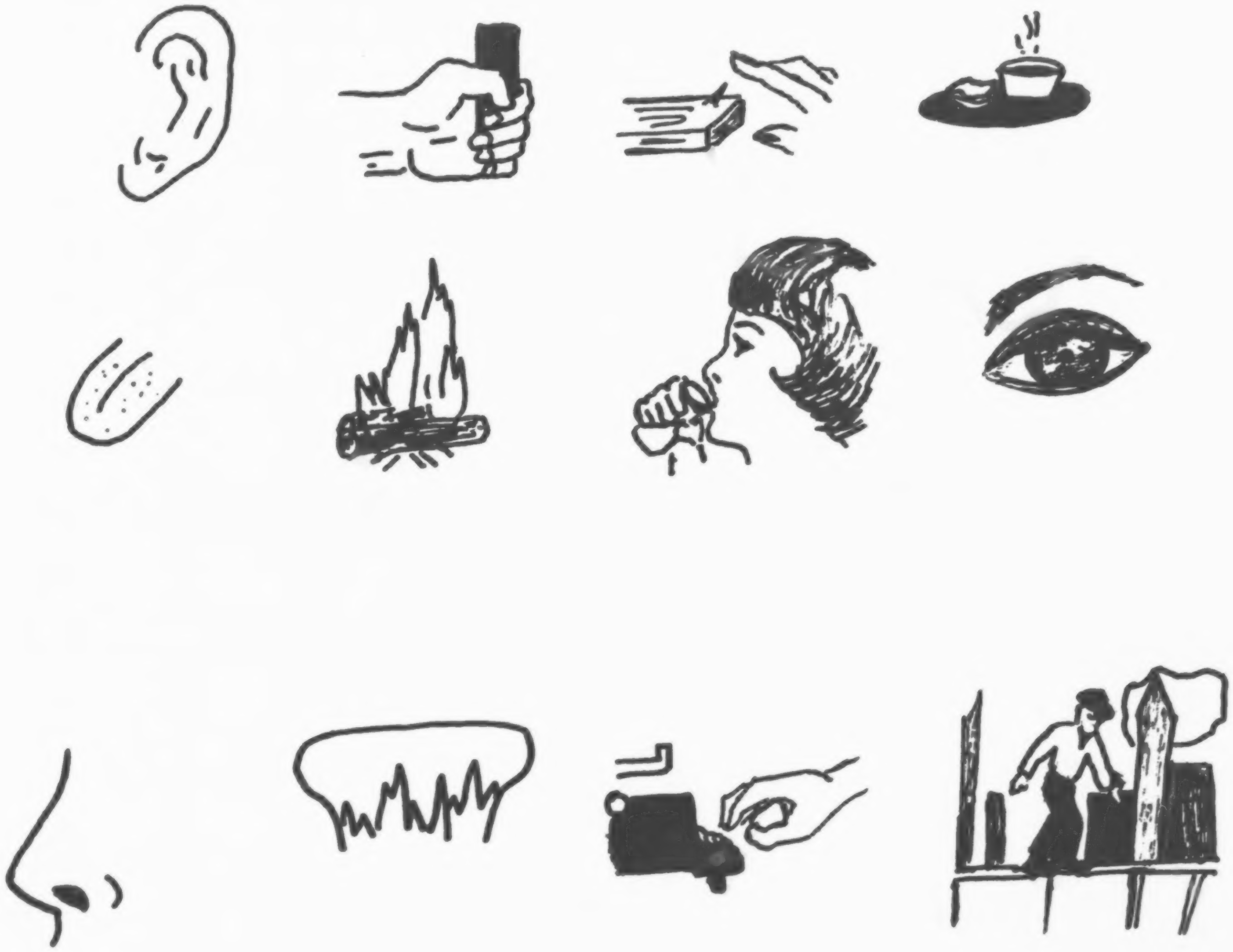
Touch Sense --

Sense organs in the skin enable man to feel warm, cold, pain and the like. These are primarily the senses of touch. One gets some idea of this loss of tactile sensation when an arm or leg "goes to sleep."

Without the so-called tactile senses one could not know when something was too hot, too cold, and would in a sense be defenseless.

There is great necessity for many kinds of senses working for you all the time and making one aware of constant changes taking place in the environment.

HOW MANY SENSES DO WE HAVE?



Redrawn from: Liberty, Gene, Robert Tidd. The First Book of Human Senses. (New York: Franklin Watts, Incorporated.)

Our knowledge of the human senses is growing. In past years, we thought that we had only five senses: sight, hearing, taste, smell, and touch. As we gain deeper wisdom about our bodies, we are learning that there are many more human senses than the original five.

We now know, for example, that touch is one group of senses called the feeling senses. The other feeling senses are pressure, heat, cold and pain. In addition we recognize today that hunger, thirst, muscle sense and balance are separate senses.

Our present list of senses, some of which are shown on the preceding page, has grown to more than twenty.

Problem: What are some kinds of information we receive from our senses?

Experience:

Hold the tips of two toothpicks one-fourth inch apart. Ask a student to close his eyes. Press the tips of the toothpicks firmly but gently on his forearm and ask how many toothpicks he feels. Try this same procedure on the back of his neck, the palm of his hand, the back of his hand, the tip of his forefinger, and the tip of his tongue. Vary the distance between the tips of the toothpicks and sometimes use only one toothpick. Where are the most accurate sensations of touch to be found?

Experience:

Ask a student to stand on one leg for a minute. Is it difficult for him to keep his balance? Have him close his eyes and stand on one leg. Is it more difficult with the eyes closed? How does he know when he is getting off balance? What senses are involved in maintaining upright posture?

Experience:

Have someone place a student's hand in a pan of water as hot as it can by without being painful. After a minute in hot water, have him put his hand in a pan of lukewarm water, and ask him to describe its temperature. Repeat the same procedure using ice water instead of hot water? How accurate are our senses?

Problem: How do we taste foods?

Experience:

Prepare some thin slices of raw apple and raw potato. Ask a student to hold his nose and chew a slice of apple. Would he know it was apple from tasting it? Have other students close their eyes and hold their noses. Give each a slice of apple or potato to chew. Can they tell what they are chewing? What other senses work with taste to give us information about the food we eat?

Problem: How do we recognize tastes?

Experience:

Get some clean cotton swabs, table salt, sugar, and some lemon juice. Moisten a swab with water, dip it in sugar and apply it to the back, sides, and tip of your tongue. Where is sweetness tasted?

Experience:

Try this same procedure with salt and lemon juice, using a different swab for each. Which parts of the tongue respond to the salty, sweet, or sour tastes? After trying this on several students, record which part of the tongue it was recognized.

MAN'S SENSES: THEIR LIMITATIONS AND EXTENTIONS

Experience I:

Blindfold a student and hand him an object he hasn't seen. Let him examine the object in any way he can, except by sight. Hide the object and remove the blindfold. Have the pupil make a drawing of the object and describe it to the class. Bring out the object and let him compare it with his description.

Question: Were the other senses as accurate as sight?

Answer:

Experience 2:

Blindfold a student and have him sit in the center of the room while the rest of the class is seated quietly around the walls of the room. Have him cover one ear and move a loud-ticking alarm clock around the room.

Question: How closely can he determine the direction of the clock?

Repeat the experiment, this time using both ears.

Question: Can one determine direction of a sound better with one ear or with both of his ears?

MAN'S NERVOUS SYSTEM

Experiences with Questions and Answers

Experience I: Bump your elbow gently on your "funny bone."

Question: What do you feel?

Answer: A "tingling" is felt, which has gone to the spinal column and stimulated the peripheral nerves which connect with the elbow.

Experience II: Blindfold a person after he sees a rod being heated. Then touch that person with an ice-cold rod.

Question: How did this person react to the experience?

Answer: He will cry out in pain, thinking he has been burned because the nervous system cannot rapidly distinguish between hot and cold objects.

What are some examples of reflex responses?

Experience I: Have someone sit on a desk or table so that his feet do not touch the floor and his legs can swing freely. With the edge of your hand held flat, tap one of his knees firmly just below the kneecap. What response occurs? Is it a voluntary response?

Experience II: Pretend to yawn when several people are watching you. Do any of the others yawn? Is yawning a conscious response?

Experience III: Watch the eyes of the person who sits next to you. Approximately how often does he blink? Move your hand suddenly toward his face. Does he blink in response? Have him try not to blink as you move your hand quickly toward his face again. Can he consciously control blinking? How is blinking a protective reflex? What other useful functions does blinking have?

Experience IV: On a playground toss a soft ball to someone who is not expecting it. What responses does he make? Did he have to think about the responses he made? Were any of the responses learned? If so, which ones?

EVALUATION

1. What is the nervous system and what does it do for you?
2. What are the three main parts of the nervous system? What does each include?
3. How does your body control its regular activities?
4. Name three tissues that make up the nervous system and tell what each one does.
5. In what way do neurons look different from most cells?
6. Which part of a neuron carries impulses?
7. What are nerves?
8. Discuss some differences between sensory nerves and sympathetic nerves in the autonomic nervous system.
9. Where are association neurons found in the nervous system? What is the function of this portion of the brain?
10. What is meant by a reflex action? Give an example.
11. How does the nervous system control the actions of the muscles and glands?
12. What do sense organs do? Give some examples.
13. Where does a sensory nerve transmit impulses to the next nerve cell toward the brain?
14. What different factors in the environment stimulate the sensory nerve endings?

How Is Man Aware of His Surroundings?

Through his perception man becomes aware of his surroundings. When an individual perceives he is engaging in an on-the-spot experience with personal interpretation.

Look at your book; look at the printed page. What do you see: A set of printed words? A block type? Can you single out the curved lines, the straight lines and the general shape of the letters? At this moment you are perceiving. How are you doing this? You are perceiving by means of your senses whose impulses are interpreted by your brain.

Your sense of sight enables you to read the title of an article. The block of type is outside your body but it reaches your brain through sight. A sense of sight, in turn, is dependent upon something else. To see, you must have light. Light is a form of energy.

Some form of energy is always necessary before you can perceive. Energy must reach a part of your body. It must go into your eyes, your ears, your skin, your nose, or your tongue. Energy, you see, activates your senses--your sense of sight, your sense of hearing, your sense of touch, your sense of taste, and your sense of smell.

Physical contact is the first link in the chain of sensory perception. The perceiver makes contact with an event or an object by responding to light, heat, sound, chemicals, or pressure and, as a result, he registers reactions.

When we look at the stars at night we make contact with a part of our surroundings through light energy. Light from the stars enters our eyes and forms an image on the retina of each eye. Our optic nerve transmits the sensory message to the brain. The perceiver thus becomes aware of the stars presence in his surroundings.

The light, heat, sound, chemicals, or pressure causing a reaction in the brain of the perceiver are called a stimulus. The body parts that first detect a stimulus are called receptors. Generally, receptors are known as either sense cells or sense organs. The taste buds on your tongue are made up of sense cells. Your eyes are sense organs.

Every sense cell and sense organ is sensitive to specific kinds of stimuli. The eyes respond to light, the nose and mouth respond to chemicals, while the finger tips respond to heat and various pressures. Sense cells and organs contain millions of receptors. It has been calculated that there are more than four million pain receptors in the human skin.

You are probably familiar with our five senses--the senses of sight, hearing, smell, taste, and touch. This idea of five senses is somewhat misleading. In reality, the human body responds to more than twenty sensations, or senses.

Therefore, senses, are more specifically the twenty odd sensations that we possess, making us aware of all the factors that compose our environment.

Experiment:

> Select three colorless liquids. For example, water, ammonia, and white vinegar. Put the liquids into capped bottles. Can you identify the three liquids by looking at them? No. Remove the bottle caps. Can you tell the liquids apart by their odors? Only two of them, ammonia, and white vinegar. What can you conclude about the odorless liquid? You are unable to detect its nature or composition through the sense of smell and must employ another sense in order to be made aware of the nature of the liquid.

(Information for this article was taken from Today's Basic Science by Navarra, Zaforoni and Garone)

How am I aware of my surroundings?
Man's senses: their limitations and extentions

Man has five major senses: Touch (tactile), taste, sight, hearing, and smell.

Touch: The sensory nerves of the skin transmit sensations of pressure, pain, heat, and cold from the specific sense organs to the proper parts of the central nervous system to be interpreted. Special sense organs in the muscles, called muscle spindles, originate the so-called muscle sense to tell the degree of contraction or general condition of the muscles.

Taste: The human taste buds are the end organs of nerve filaments arising from the trigeminal, facial, and glossopharyngeal nerves (the ninth pair of cranial nerves). The taste organs are located chiefly on the tongue, but are also found on the palate, epiglottis, and even on the vocal folds.

Hearing: The human auditory apparatus consists of:

1. An external ear with its auditory canal having a membranous tympanum (eardrum) at its inner end;

2. The middle ear with its Eustachian tube connecting it with the pharynx to equalize air pressure; the middle ear bones, the hammer or malleus, the anvil or incus, and the stirrup or stapes; the two openings of the fenestra vestibuli and the fenestra cochleas;

3. The internal ear with its vestibule, its snail-shell-like cochlea, and the three semi-circular canals (the semicircular canals serve to help to supply the body with a sense of equilibrium);

4. The auditory or acoustic nerve, leading from the internal ear to the central nervous system.

Sight: The human visual apparatus consists of:

1. The eyeballs with six muscles for eye movement;

2. The lacrimal apparatus to keep the eye moist and protect it;

3. The conjuctiva or mucous membrane lining of the eyelids internally, and the outer covering of the eyeballs;

4. The eyebrows, for protection;

5. The complicated apparatus of lens, aqueous humor, vitreous body, iris, pupil, cornea, and the sensitive retina, choroid coat, the sclera, etc. within the eye.

2 neg

6. And the optic nerve, which transmits the stimuli recorded by the retina to the visual centers of the brain where the sensation of sight is really located.

Smell: The human olfactory apparatus consists of a fine network of olfactory nerves spread from the irregular surfaces of the superior nasal cochlea and upper nasal cochlae and upper nasal septum. These nerves terminate in olfactory cells, each with six to eight hair-like processes. The olfactory cells are affected by small particles of solids or gases in solution. The olfactory nerve carries impulses to the olfactory center of the brain.

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CHAPTER III

WHY ARE JUNIOR HIGH SCHOOL PEOPLE SO VARIED IN BUILD, SHAPE, AND STRENGTH?

OBJECTIVES

I may find some answers by exploring the following questions:

1. What is inheritance?
2. How are characteristics passed from one generation to another?
3. What are the chemical regulators?
4. How do ductless glands function to regulate body growth?

GROWTH PATTERNS IN GENERAL AND THEIR HEREDITARY ORIGIN

Adolescence has been called the second infancy. There is a parallel between the marked increase in body size and weight in infancy and the gain in height and weight of adolescence. Naturally, however, the infant is not aware of his weight and height increases, although these are followed with great interest by his parents, grandparents, and doctors. Nevertheless, the teenager shares the interest and excitement about his physical changes.

One may ask, "Just when do all these things happen? How about a timetable?" The answer is different with each individual. Boys, on the average, are about two years behind the girls in beginning their adolescent spurt, and in showing signs of having reached puberty, but, here again, individual variation is great. Since people are all individuals instead of statistics, what happens to each person is what is important, and not the sum total of what happens to a large group.

Puberty is that period of life during which the reproductive organs and secondary sex characteristics mature. In the female, it is usually considered that puberty begins with the first menstrual period, but this is not a very dependable criterion. For the male, it is more difficult to fix a specific time as indicating the beginning of puberty, but such conditions as the need for occasional shaving, the deepening of the voice, and the rapid growth of the external sex organs may be noted.

A careful study of the children who rightfully belong in a three-year junior high school shows that (1) they are primarily children twelve to sixteen years of age; (2) most of them are physiologically either maturing or mature; (3) they differ more widely among themselves from the standpoint of interests, attitudes, and achievements than at any previous age level; (4) they have not yet completed the education which all need in common; and (5) they increasingly face the necessity, as they advance through this age interval, of making important educational and occupational choices.

Before or at the onset of puberty, there is a very rapid increase in height, with growth spurts of from two to four inches taking place within a few months. The flesh, or subcutaneous tissue (under the skin tissue) becomes more noticeable in junior high children, with an increase of muscular tissue as well. At this age the posture changes to a straighter, more adult posture, although mannerisms such as the thrust-forward head and various types of slouches may change the more natural walk of the adolescent. The unsureness an adolescent feels about the way he or she looks often changes his posture and gait to a "cowering type" of shoulder-forward, body-curved-backward type which worries parents.

Thus, the physical changes of junior high children are manifold, involving changes in height, weight, posture, tissue, and body configuration.

Some of these pronounced changes are as follows:

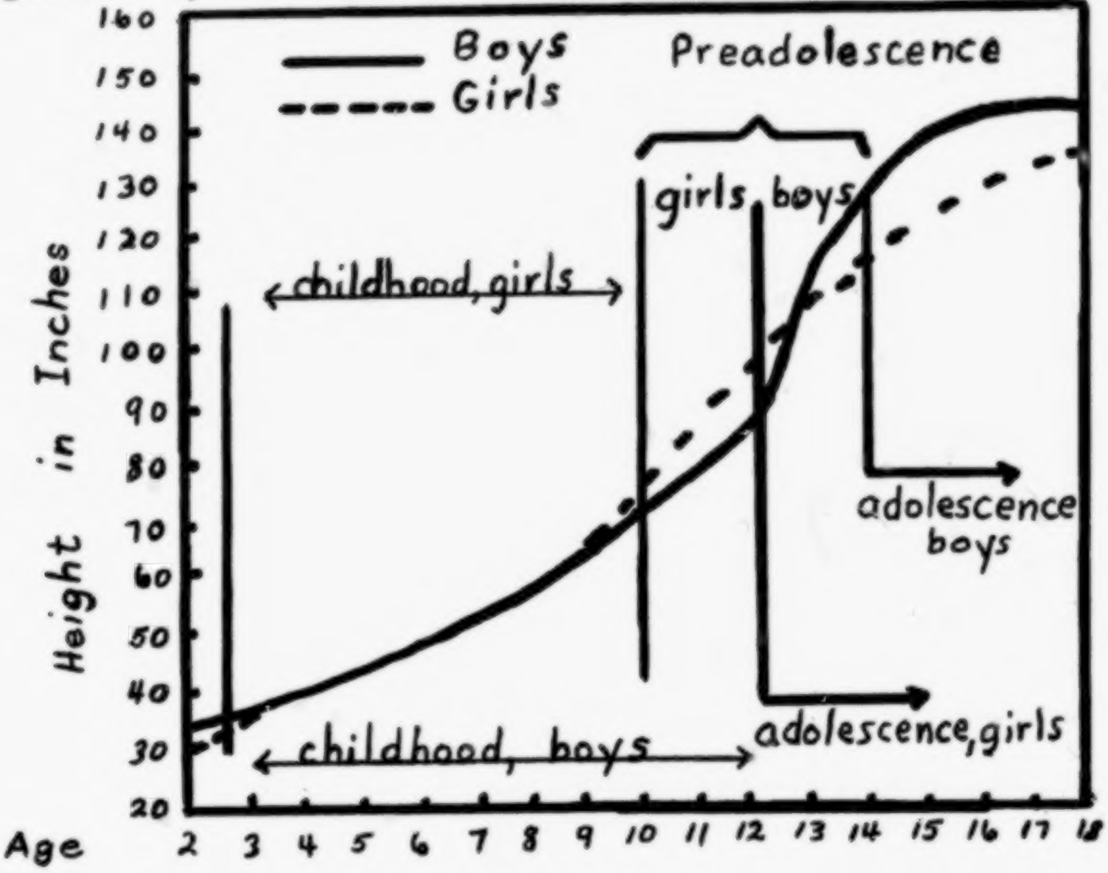
1. Shoulders become broader, particularly in young men, while hips and buttocks spread in the young ladies.
2. Breast and chest development occur respectively, as girls become women and as boys develop into men.
3. The skin changes in texture, and because its increase in oiliness, many junior high school children get pimples, blackheads, and other irritations.
4. Perspiration often becomes profuse.
5. Hair grows in some places of the body where it was inconspicuous before--the pubic region, the armpits, and the outer surfaces of the arms and legs.
6. The boy's voice changes from one which recently sounded like his mother's or sister's, to a ragged state of squeaks and growls, and the deeper male voice.
7. The sex organs, the genitals, make rapid and distinct changes in boys and girls.

A few years ago studies on weight of the adolescent involved only two factors: (1) the age and (2) weight of the individual. Then the third factor, height, was added. More recently, however, another very significant factor has been added; the age at which the individual has reached, or will reach puberty. It has been found that when puberty is reached early, the accompanying spurt of height and weight puts a youngster way ahead of most of his age group. The edge is only a temporary one, however, because as the other youngsters reach this phase they also grow rapidly.

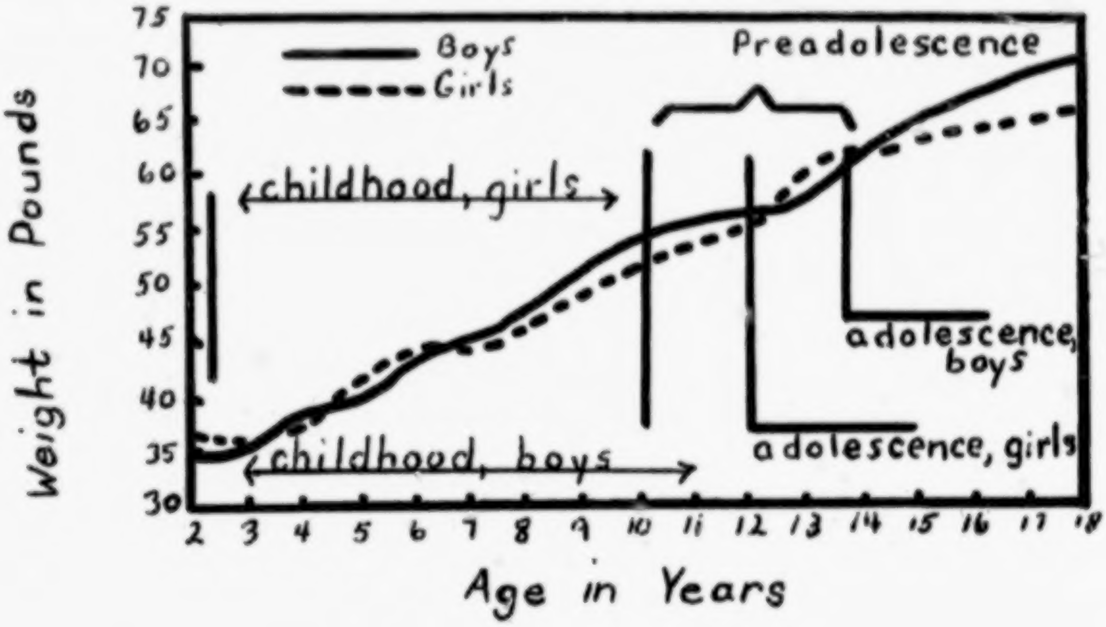
Doctors and researchers are beginning to realize that with heights and weights, as well as with age of onset of puberty, the average statistics are not so important as discovering the wide range of normal statistics. Within this range of normal statistics the healthy individual may be just right for his height, developmental stage, and body build.

No two organisms are exactly alike. Take a litter of kittens or puppies. Examine them to see if they all look the same, or can you tell one from the other? It's the same way with people. How many poeple in your class look the same? Even with twins there is always some difference. This fundamental characteristic, that no two organisms are exactly alike, is called variability. How are these differences produced?

There are several growth patterns during adolescence; one of these is height. Have you noticed that in the seventh and eighth grades the girls are often taller than the boys? Will these same girls be taller than the boys when they are high school seniors? Probably not, since boys grow rapidly from about fourteen years of age to seventeen or eighteen. By this time the boys are usually taller than the girls.



Weight increase is another thing that changes from time to time during a person's life. For example, the greatest weight increase is during the first three years. Later, as some of these people reach their teens they are overweight, but unless there is some disorder these same students will begin to "slim-down" when they get into high school. There are others who are too thin when they reach adolescence, but tend to develop with a later growth spurt.



Sometimes the cause of unusual shortness of stature during this adolescent period may be heart trouble, kidney disease, vitamin deficiency, or abnormal function of the pituitary gland. All of these possible causes make up a very small percentage of the large number of youngsters who are shorter than average. In most cases these temporary growth abnormalities adjust themselves with time.

The body develops muscular coordination at different times during growth. This growth development can be traced chronologically, as seen in the following chart (from The Psychology of Adolescent Development by Raymond G. Kuhlen).

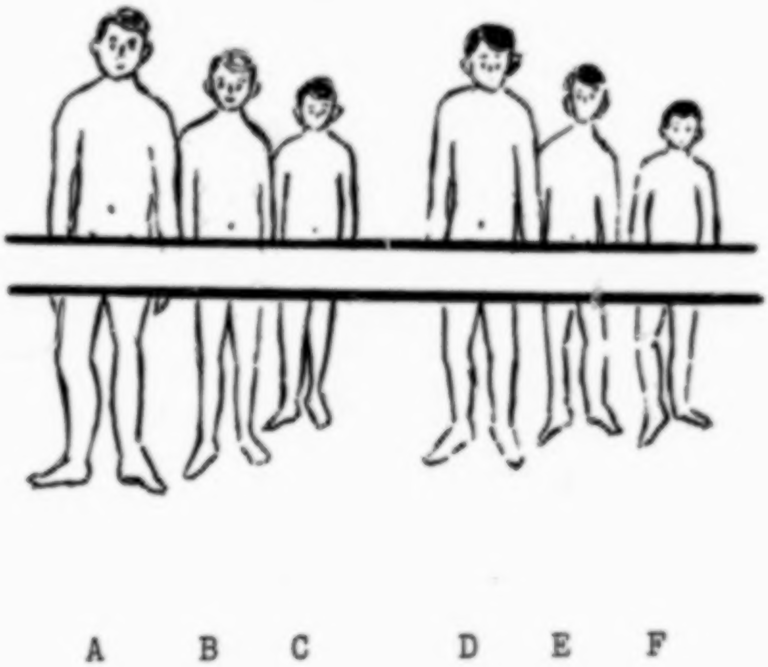
Birth - 2 years	Infancy	Learns to control muscles for body movement.
2 - - 10 years	Childhood	Develops coordination of large muscles for body activities.
10 - - 16 years	Adolescence	Develops coordination of smaller muscles for fine skills.
16 - - years on	Adulthood	Develops judgment and control of activities.

Clear sex differences are apparent in strength. Boys, on the average, have the edge over girls all through childhood and widen the gap markedly in the late teens. The rate of development of strength appears to have a close relationship to the advent of pubescence. As might be expected, differences among individuals in strength increase markedly during the age range when pubescence occurs.

A major influence of physical growth on adjustment occurs when a person fails to recognize the fact that individuals mature at different rates. The adolescent notices not only the change occurring in himself, but also changes in his relative status as compared with others. Therefore, it is of psychological significance that individual differences become greater at pubescence.

Final size and body structure appear to bear some relation to age of pubescence, but the relationship is not necessarily the same for both sexes. Early-maturing boys tend to be taller than the average at adulthood, whereas early-maturing girls show a slight tendency to be shorter at maturity. Individuals who mature early tend to have relatively broad hips and narrow shoulders, while those who mature late have relatively broad shoulders and narrow hips.

The reasons for individual differences in size and growth are to be found in a variety of conditions: heredity, nutrition, illness, exercise, and climate. Relatively little is known regarding the specific effects of these various factors individually, though all operate simultaneously and interrelatedly. It is probable, however, that hereditary factors are in one way or another primarily responsible for the ages at which growth starts, the pattern that it follows, and the outcome in bodily structure. Other factors attributable to genetic inheritance are eye color, color blindness, baldness, and general facial and body features. These hereditary factors show many similarities between parents and children.



The three boys in the left-hand group (A, B, C) are all the same age - 15 years. A is postpubescent, B is pubescent, and C is prepubescent.

In the instance of the three boys on the right (D, E, F) the largest is the youngest and the smallest is the oldest. D is thirteen years, one month old and postpubescent, E is thirteen years, five months old and pubescent, and F is fourteen, six months and is prepubescent.

What Is Inheritance?

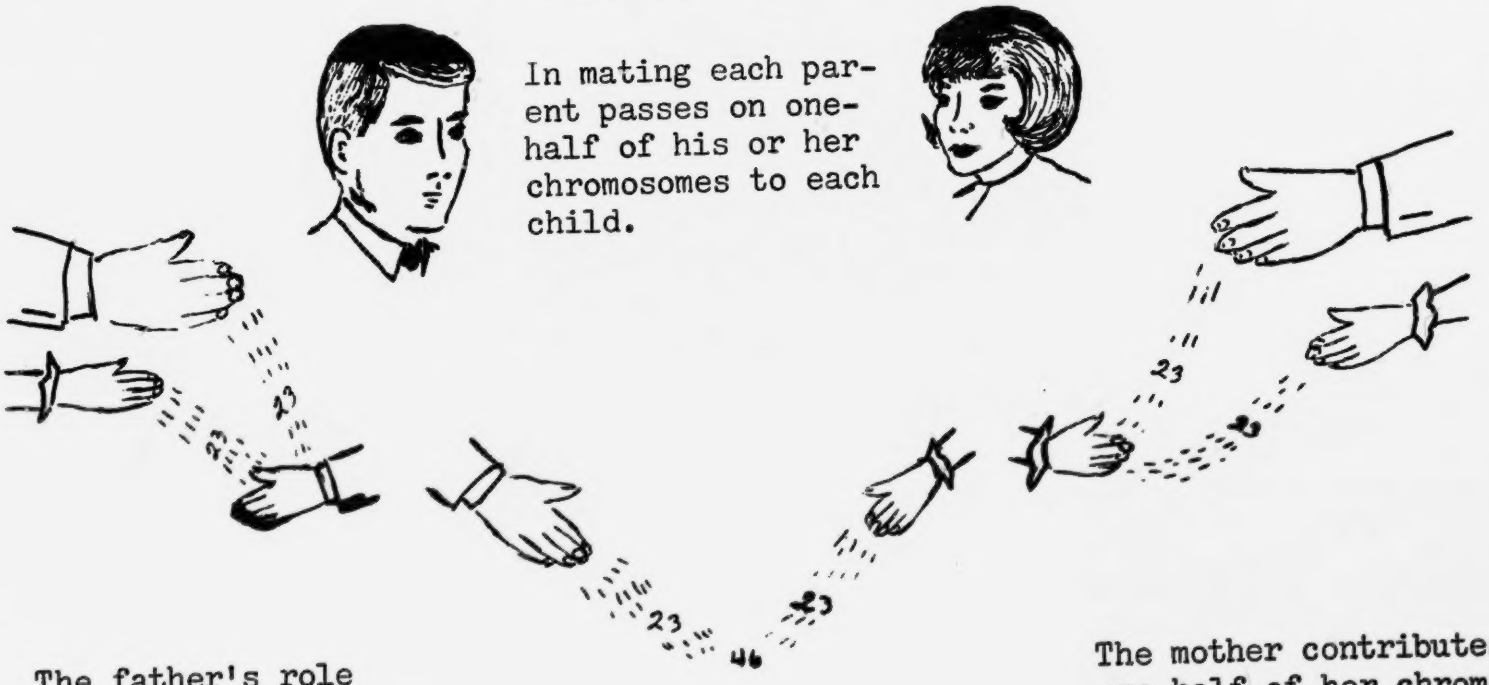
Living things look similar to all others of the same species. In other words you do not have trouble telling the difference between a horse and a cow. All horses and cows have certain characteristics or traits that are similar to other horses and cows. In the same way, humans have traits that are common to all humans. We walk on two legs; we have hands for grasping; and we have a highly developed nervous system. These traits are known as species characteristics. All children inherit, or receive from their parents, the characteristics of the human species.

Children also inherit a combination of individual characteristics which make them a little different from all other humans (except in the event of identical twins where environment still makes them different). These characteristics are inherited from their parents. The child may look like one parent in some ways and like the other parent in others. An example of this is one parent has brown eyes and red hair while the other has blond hair and blue eyes. When the offspring has brown eyes and blond hair, we can say these are characteristics of both parents.

How do we inherit our uniqueness from our ancestors?

By now each of us knows that our body developed from a single cell about one-seventh of a millimeter or 1/175 of an inch in diameter. This cell had 46 chromosomes; 23 from our mother and 23 from our father. Since our parents each had a full set of 46 chromosomes, chance determined which 23 were passed on to us, the offspring. We can see that, as we trace our ancestry back, any one ancestor's contribution to our being is small: the parents each contribute one-half; the grandparents each contribute one-fourth; and great grandparents each contribute one-eighth. Since only one-half of each ancestor's genes were passed on to us, only one-sixteenth of our genetic make-up is like a single great grandparent. We are each more like our parents than any other ancestor.

The Heredity Process



In mating each parent passes on one-half of his or her chromosomes to each child.

The father's role is that of passing on one-half of his chromosomes by sperm.

The mother contributes one-half of her chromosomes to the child through the nucleus of the egg. She also contributes almost all of the cytoplasm of the fertilized cell and in addition, furnishes her body as an incubator where the fetus is nourished for the prenatal period of development.

These 46 chromosomes act as the determiners of heredity and together with the environmental influences, develop the characteristics of the offspring.

Only 23 of the 46 chromosomes will be by chance passed on to the next generation. The effects of the environment are not transmitted through germplasm.

The Heredity Process is adapted from The New You and Heredity, p. 10.

Each of the 23 matched pairs of chromosomes in a germ cell of a human being is estimated to contain between 500 to 5000 primary hereditary units called "genes." The total compliment of genes for 46 chromosomes varies, it is estimated from 20,000 to 200,000 genes (Montagu, 1959, p. 33).

If chromosomes pairs have corresponding matched genes, as compiled evidence indicates, the interaction of these genes expressed in relation to the human's environment determines the nature of the trait or characteristic affected by the gene.

Research evidence indicates that some human traits are carried by dominant genes while others are carried by recessive genes. From the postulation that genes normally occur in matched pairs in each individual, it is further inferred that pairings, other than recessive genes with recessive genes, will result in the exhibition of the dominant trait.

If we accept as established fact that the gene for brown eyes is dominant and the gene for blue eyes is recessive, let's see how a blue-eyed child could have two brown-eyed parents.

Since blue eyes are the expression of a recessive trait the child would bear two paired recessive genes for blue eyes. One of the paired genes would have come from each parent. Therefore, each of the parents carried one gene for blue eyes paired with a gene for brown eyes. Since a gene for brown eyes is dominant to a gene for blue eyes, each parent exhibited the trait in the form of brown eyes.

Occasionally a blending of characteristics may occur. For example, if the father has dark brown hair and the mother has blond hair, the offspring may have light brown hair.

Some characteristics may be inherited by only the male progeny or by only the female progeny. An example of this is baldness. Baldness tends to be inherited by only males. It is interesting to note that even the shape of the bald spot seems to be inherited. (See chart on following page.)

It is rather interesting that shortness appears to be more dominant than tallness. Two medium height parents may have children that attain different heights, between short, medium, and tall, if both parents are carrying both short and tall genes. However, two tall parents tend to have children who become tall because the parents carry paired genes for tallness which are recessive. With a tall and short parent the children tend to become taller than the shorter parent showing that the genes affecting height must have a cumulative effect.

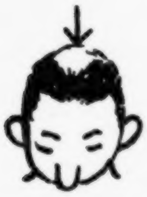
An albino is a person or animal born without any coloring in the body. The skin is very light, the hair is white, and eyes pink. This condition is caused by a mutation in the color of the cells in the body. White mice are a good example of this.

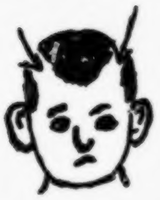
Mutations are new traits that appear suddenly in an offspring. It then becomes a family trait or characteristic for that individual and can be passed on to the next generation.

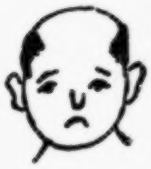
Heredity is difficult to study in humans because it takes a long time to produce new generations. However, scientists have studied some families for several generations, and the evidence shows that human inheritance follows the same heredity patterns and laws that apply to

CHART NO. 3

Inherited Pattern Baldness


Starting at center of crown.


Starting at temples.


Over whole top of head.

How Baldness Is Inherited

Ʊ ---- Normal Hair Gene (symbol).

O ---- Baldness Gene (symbol). Dominant in men. One baldness gene produces baldness. Recessive in women or completely supressed. Two baldness genes are required to produce any degree of baldness in women.

Men

Type A

O O

Two Baldness Genes (All of this man's sons will be bald, and if wife is Type A, daughter will also exhibit some of the baldness trait.)

O O

Two Baldness Genes. (Produces thin hair or partial baldness in women. All sons will be bald.)

Type B

O Ʊ

Single Baldness Gene.(Same effect as two genes, but only one in two sons of this man will be bald.)

O Ʊ

Single Baldness Gene. (No effect on woman herself, but one in two sons will be bald.)

Type C

Ʊ Ʊ

Two Normal Genes. (No baldness in this man's sons unless his wife is type A or B.)

Ʊ Ʊ

Two Normal Genes. (No baldness in this woman's sons unless her husband is bald.)

all living things.

The study of heredity has been helped through the study of identical twins. For all practical purposes, identical twins are the same person, but doubled: they both developed from the same egg cell which somehow split into two parts and became two individuals. Although identical twins look alike, developed in the same way, and usually behave somewhat alike, there are distinct differences. Scientists believe, that many of these differences are caused by the environment in which the children grow up. In other words, the characteristics that are exactly alike were inherited, while the behavior traits that are a little different in identical twins, were probably caused by their environment. One might say that even though they are identical twins, they have different personalities.

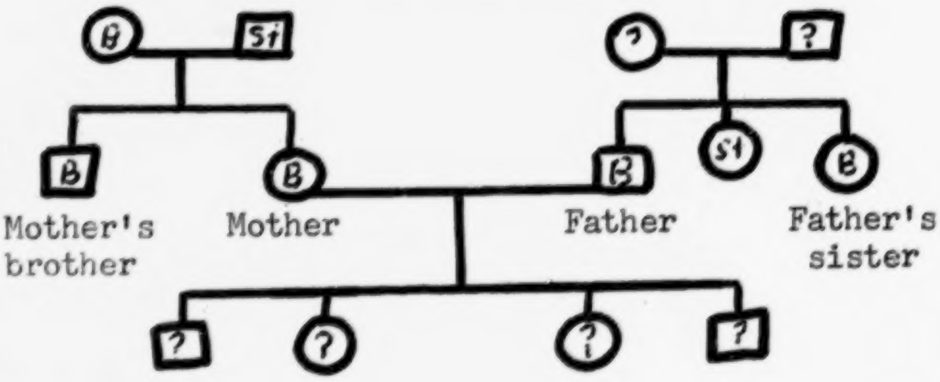
What would happen if identical twins were separated at birth and brought up under different environmental conditions? Would both twins develop along the same lines? Many cases involving separated twins have been reported in research literature.

All the characteristics you inherit, plus those you acquire from your environment, determine your personality. You cannot change your inherited characteristics, but you do form personal bias and habits of behavior in response to your interpretation of your environment. These can be changed.

Experience: One simple heredity test that the class may run is the family taste test. Give each student a chart and a slip of paper treated with P. T. C. (Phenyl thiocarbamide. P. T. C. may be obtained from the General Biology Supply House, 8211 Hoyne Ave., Chicago, Ill.) Tell them that when chewing up a bit of the treated paper, some of them will detect a definite taste. Others will taste nothing. These peculiarities in taste discrimination are inherited according to Mendel's Law.

Legend: A - acid or sour
B - bitter
C - no taste
St - salty
Y - others (please specify)
☐ - male
○ - female

SAMPLE CHART
FOR PCT TEST RESULTS



Tongue rolling ability where the sides of the tongue are rolled up above the center as the tip of the tongue is barely projected from the mouth, is a simple dominant trait exhibited by about 65% of the population. Conversely, the inability to roll the tongue is a recessive trait exhibited by about 35% of the population. This is an ability of no practical use that students might like to investigate with their own family or within the class.

Apart from identical twins have you ever seen any two people who looked exactly alike? You haven't and you never will. You never will because of the fact of variability--no two things are ever exactly alike--a fact that applies to all living things. For man the fact of natural variability is the best assurance against the dulling effects of uniformity and the nightmarish threats of totalitarianism.

What is the meaning of all this variation? Observe how different people are, in their appearance and in their behavior. In your own family, consider how each member differs from the others, and yet how remarkably they resemble each other in some of their features and even in their mannerisms. The resemblance may be in the shape and form of the nose, the color of the eyes, body structure, the walk, hand-movement mannerisms, and the like. One is very fond of music, another cannot carry a tune. One is allergic to pollens, another is not, and so on. How do all these likenesses and differences come about in the same family and in different families? Why do people vary in intelligence? Which is stronger, heredity or environment?

The questions just asked, and others of a similar sort are all the concern of the science of heredity, genetics. Genetics is the branch of biology concerned with the manner in which inherited differences and resemblances come into being between similar organisms.

For many years it was believed and taught that the human fetus is so well insulated within the womb from the rest of the world, including its mother, that what went on outside the womb, was, on the whole, unlikely to affect the fetus. In recent years, this belief has been proven untrue. The human embryo, the term we give to the human organism from conception to the end of the eighth week, is extremely sensitive to all sorts of changes in the mother and in the external world.

Since a great many physical and mental defects in children are believed to be due to disturbances occurring during the prenatal (before birth) development of the organism, it is important to know how these come about, for with the knowledge gained we will be in a better position to control the situation.

The effect of environmental factors upon the development of the prenatal organism may be considered under the following ten headings:

(1) maternal age, (2) maternal parity, (3) maternal dysfunction, (4) maternal sensitization, (5) nutritional effects, (6) infections, (7) drugs, (8) physical agents, (9) emotional factors, and (10) other environmental factors.

Maternal Age--It has been found that mothers between seventeen and twenty do better than the mothers in a younger age group, but not as well as the mothers in the twenty-one to twenty-eight age group. From the age of twenty-nine onward there is a rise in maternal and infant mortality rates. Evidence suggests that the youngest group of mothers give birth to children with more birth defects because their bodies are not fully prepared for all the processes of motherhood and, likewise, that the reason mothers over 29 give birth to children with higher defect rates is that their bodies are losing effective capability in all processes of motherhood. The diet and physical conditioning of women, years before they become pregnant, have been shown to affect the rate of birth defects and general vigor of the babies. Drugs, including nicotine, taken during pregnancies, have in recent years been shown to increase the rate of birth defects.

Maternal Parity--It is now well established that firstborn children, as well as those born at the end of a long series of pregnancies, are less able to live than those born in between, irrespective of maternal age.

Maternal Dysfunction--"Maternal dysfunction" describes non-infectious functional disorder and/or diseases in the pregnant mother. These maternal dysfunctions may affect the development of the fetus.

Maternal Sensitization--In some cases the genes of mother and fetus differ in the substances borne on the surfaces of the red blood corpuscles. As a result the mother may become sensitized and produce antibodies which unfavorably affect the development of the fetus.

Nutritional Effects--Possibly the most important factor in influencing the development of the fetus is the nutrition it receives from its mother. The food consumed by the mother is reduced to molecules which are able to pass directly through the placenta into the fetal blood stream. It is generally agreed that when nutrition during pregnancy is inadequate the fetus suffers more than the mother.

Infections--It has been found that some viruses and bacteria are capable of passing from the mother to the fetus. These interfere with the development of the child and do considerable damage to the offspring.

Drugs--Drugs taken by the pregnant mother may seriously affect the fetus. It has been found that there is a significant correlation between the number of cigarettes smoked each day, during pregnancy, by mothers and the frequency with which these mothers gave birth to premature babies.

Physical Agents--Deformity may be caused by faulty positions, mechanical shaking, temperature changes, umbilical cord entanglements, exposure to massive doses of X-rays, sudden loud noises and vibrations, and the birth process itself.

Emotional Factors--Children born of mothers who have been seriously distrubed emotionally at sometime during pregnancy frequently exhibit psychological and psychosomatic irritability after birth. Emotional factors are known to play an important role in habitual miscarriage and sterility.

Other Environmental Factors--The direct and indirect effects upon the fetus of radiation from the fallout of atomic bombs is becoming more important each year. In areas of the world where the soil is deficient in iodine, the fetus develops an iodine deficiency just as do individuals living in that area. This, in turn, may lead to endemic cretenism, caused by a congenital deficiency of the thyroid gland. Cretins suffer from an almost complete lack of the thyroid hormone and are stunted both physically and mentally. They are often more or less deaf. After the child is born and begins to grow, the power of heredity is often strikingly exhibited in the shape and size of the nose, the shape of the chin, the formation of the teeth, and the ear characteristics.

There are a large variety of body forms from short and broad (endomorph), to broad-chested, muscular (mesomorph), to tall and scrawny (ectomorph). There have been many different schemes by which the body has been classified, but not one of them has thus far proved satisfactory for practical classification of members of a family, or the general population. This fact and the complex nature of body form with its many contributing factors makes studies in human heredity, in this area, more of a challenge than an accomplished fact.

Heredity, of course, does not operate in a vacuum, but in an environment which can influence the direction and extent of development that hereditary traits take.

When economic conditions change markedly within a family so that it is difficult to obtain adequate nutrition, children are apt to lose weight. Possibly due to better nutrition, Japanese reared in California are bigger than Japanese reared in Japan. Climate, too, has its influence.

Due either to temperature and sunshine or to more vigorous play out-of-doors (and probably greater food intake as a result) growth is more rapid in the summer. Climate apparently affects the age of pubescence. Earliest pubescence occurs in the temperate zones. Illness, special defects, or injury, growing out of environmental contacts, may affect the rate at which growth proceeds. Malfunctioning of the glands which influence growth may result in differences in body build or bony structure or in delayed puberty. Weight and the fund of physical energy, particularly, seem influenced by local infections such as diseased tonsils.

There are a number of factors--inherited and environmental--which will result in growth differences among children. Degenerate heredity, poor nutrition, and inadequate medical attention, go hand in hand, and thus have a concerted inhibiting influence upon good development. Positive factors may combine to have concerted positive influence.

GROWTH PATTERNS IN GENERAL AND HEREDITARY ORIGIN

Differential Growth Rates in Humans

In this laboratory experience you will have an opportunity to observe some simple examples of differential growth rates and their results in humans.

Materials and Equipment

Graph paper
Plain paper
Millimeter rule
Filing cards, 3" x 5"

Procedure:

1. Measure the growth of your finger and toe nails over a period

of time. Record the growth of the nail on each finger and toe of both feet on graph paper. Students may work in pairs if desired, with one to grow nails and the other to measure and record. Proceed as follows:

a. Trim each nail as short as possible for the start of the experience.

b. Measure the length of the nail from the cuticle at its base to its upper edge. Use a narrow strip cut from a 3" x 5" filing card. Mark the length of the nail as accurately as you can on the strip with a sharp pencil. Use a fresh strip for each measurement.

c. Measure the marked length on the strip of card with a millimeter rule. Record the measurement to the nearest full millimeter.

d. Every seventh day measure and record the length of the nails.

e. Continue the experience for as many weeks as you can. The longer you continue measurements, the more interesting your results will be.

2. Try to answer the following questions:

   a. Do all your nails grow at the same rate?

   b. Do your toe nails grow at the same rate as your finger nails?

   c. Do the nails on the right and left sides of your body (fingers and toes) grow at the same rate?

   d. Do all the nails on any one hand or any one foot grow at the same rate?

   e. Explain any differences you find in terms of differential growth rates.

3. Compare your results with those obtained by other members of the class. Are there differences between the growth rates of the nails of different individuals? Between boys and girls? Between children and adults?

4. Draw outline profiles of the noses of ten adults, men or women. Try to find as many different nose shapes as possible. Do the same thing for the noses of ten children your own age. In which group do you find the difference? Why? In development,

do all parts of the nose grow at the same rate? Explain the differences in the shapes of noses that you have observed in terms of differential growth rates.

5. Look at your face in full front view in a mirror. Are the two sides of your face alike? With a piece of stiff paper, cover first the left side and then the right side of your face. Are there any differences between the two sides? Imagine each side extrapolated to make a complete face. Would you be "two people"? Which side do you like better? Explain any differences between the two sides in terms of differential growth rate.

Further Investigations:

Observe other differences in a series of human subjects: shape of hands, length of fingers, shape of head, and general body build. Explain these in terms of differential growth rates. Explain the differences in body proportions of men and women in terms of differential growth rates.

EVALUATION

1. What is puberty?
2. What are some pronounced physical changes during puberty?
3. What are some conditions which influence individual differences in size and growth?
4. What is inheritance?
5. What is meant by dominant characteristics? Give examples.
6. What is meant by recessive characteristics? Give examples.
7. What is an albino? Give an example.
8. What is meant by mutations?
9. Why is heredity difficult to study in humans?
10. What is the science, genetics?
11. What are some environmental factors which affect the development of the prenatal organism?

References

Adolescence, Growth and development, genetics, puberty

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GROWTH SPURTS AND THEIR RELATION TO DUCTLESS GLANDS

Objectives

1. To learn some of the parts and functions of the endocrine system.
    - a. Pituitary
    - b. Pineal
    - c. Thyroid
    - d. Parathyroid
    - e. Thymus
    - f. Adrenals
    - g. Pancreas
    - h. Reproductive (gonads)
2. To show that the growing body goes through definite changes in developing the characteristics of an adult.
    - a. The body grows in height and weight.
    - b. The body changes rapidly during adolescnece.
    - c. The body develops muscles and nerves.
3. To show that body responses depend on reaction of endocrine glands as well as muscles and nerves.

The Endocrine System (the ductless glands and their function)

This system is made up of several separate glands, as shown in the diagram. "Endo" means within, these glands have no ducts, but secrete substances called hormones. Hormones are the chemicals produced that help control the body's activities. The hormones, released into the bloodstream by the ductless glands, are carried through the body by the circulatory system and work with the nervous system in the regulation of body activities and processes.

Physiologists know that our differing personalities can have many explanations, but in all of us hormones have a tremendous influence on appearance, temperament, and the way we act. There are few aspects of human existence with which the glands are not in some way concerned. The leader of the "gland orchestra," as physiologists call it, is the pea-sized pituitary at the base of the brain. This gland not only controls growth, but it also regulates the activities of other endocrine glands. Its hormones are needed to start secretions from other endocrine glands. Growth hormones produced by this gland control the size of the body. Too much growth hormone produces a giant, and too little of this hormone produces a midget.

The pineal gland is located in the middle of the brain, opposite from the pituitary gland. It develops in the unborn human fetus the first month of existence, and during the sixth year of life begins to regress. In many of the lower vertebrates the pineal gland is more highly developed than in man. It is found in all the mammalian group of animals. Evidence regarding the development of the pineal gland is contradictory. Despite intensive development in the field of endocrinology, in recent years, the pineal gland has largely been neglected. The evidence, however, is that the gland produces a hormone which helps to regulate the rate of body development and the onset of puberty. The only real sound argument for placing the pineal gland in the endocrine system is the fact that it is the exclusive source of melatonin which operates as a chemical messenger. We have much to learn and much to gain from further study of the pituitary and pineal glands.

The thyroid gland regulates metabolism. This gland is attached to the front part of the trachea, in the neck region. The thyroid tissue includes four other small glands called the parathyroid glands. The functions of these two glands in the body are quite separate. The thyroid glands produce thyroxin which controls the rate of heartbeat and how the body uses food and oxygen to release energy. If this gland is not functioning normally, a condition known as Cretinism, in which the child is physically stunted and mentally retarded, may result.

The parathyroids have been conclusively shown to have an important regulatory influence upon the metabolic use of calcium and phosphorus, of which bones and teeth are principally made. Both glands play an important role in maintaining the nervous system. The responsiveness of muscular and perhaps glandular tissue to stimulation is influenced by their hormones.

Recent histological studies have caused endocrinologists to identify the thymus gland as part of the lymphatic system rather than the endocrine system. No hormones have been identified.

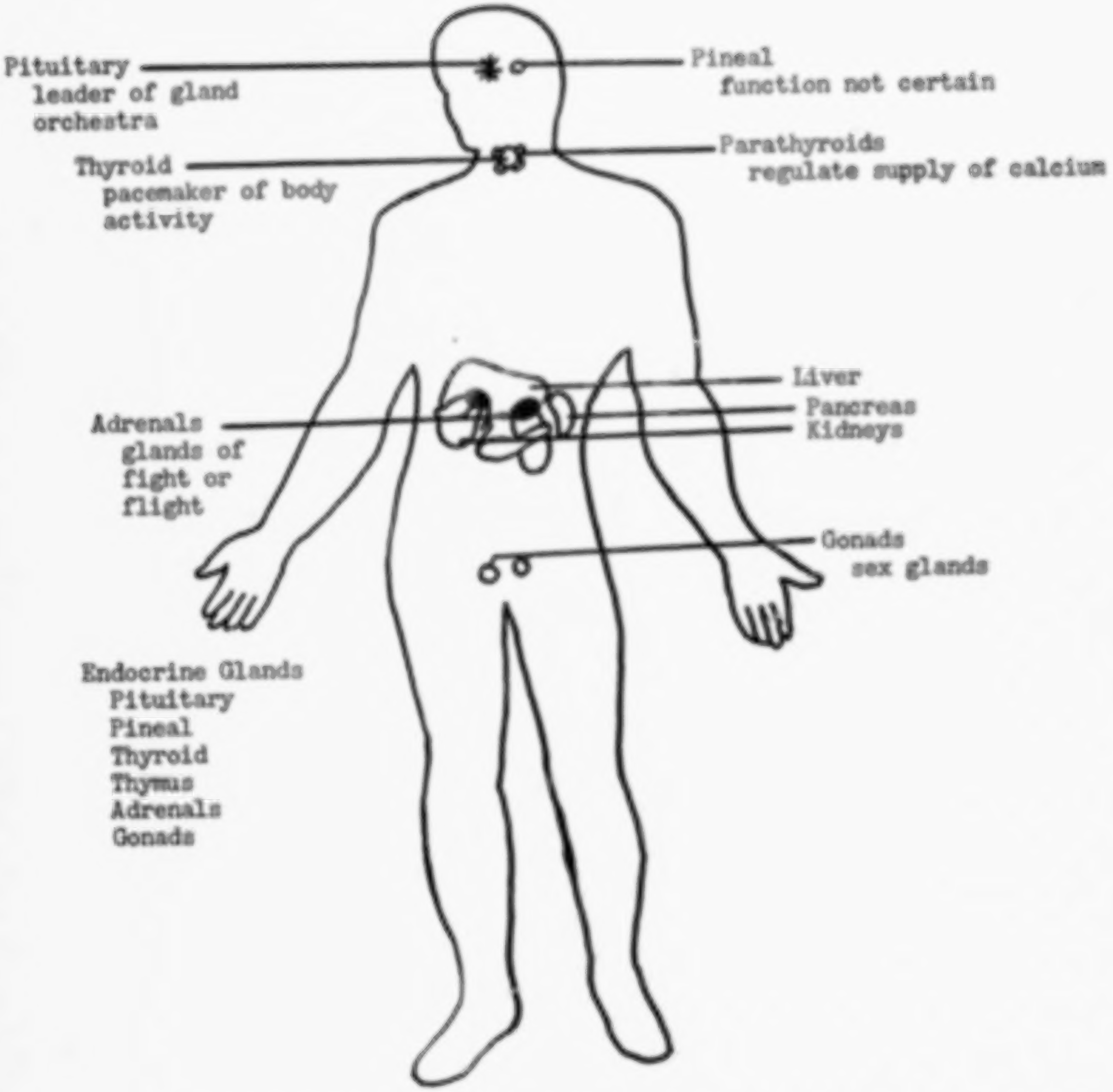
The two adrenal glands, attached to the top of the kidneys, prepare the body for emergencies. The adrenal glands produce several hormones, the best known being adrenalin. This hormone is produced when you are angry or frightened. Have you ever seen a cat's fur stand up when the cat is suddenly frightened? Adrenalin causes the muscles of the body to tighten, and in a cat the tiny muscles attached to each hair becomes tense and causes the hair to rise. This hormone also causes the liver to release sugar into the blood so that the muscles will have a good supply of energy. This is a way of protecting the body so that you are ready to fight, or to run, whichever seems the best thing to do--it regulates "fight or flight." It is the chemical from the adrenals that triggers the punch behind the blow of the angry man, or provides the sudden spurt of energy needed to jump aside at the toot of an oncoming car.

The male and femal reproductive glands are also endocrine glands. Their main function in the body is to produce sperms or eggs for reproduction, but they also produce hormones which affect the growth and development of the body, especially during the adolescent period.

THE ENDOCRINE SYSTEM

Name of gland	Hormones produced	Functions in the body
Thyroid	Thyroxin	Controls the use of food and oxygen
Adrenal	Adrenalin	Stimulates the body in case of emergency
Pancreas	Insulin	Regulates the use and storage of sugar
Parathyroid	Parathormone	Controls the use and storage of calcium
Pituitary	Many hormones	Controls growth and regulates action of other glands
Reproductive (male)	Androgen	Produces male secondary characteristics
Reproductive (female)	Estrogen	Produces female secondary sex characteristics

ENDOCRINE GLANDULAR SYSTEM


Pituitary
leader of gland orchestra
Pineal
function not certain
Thyroid
pacemaker of body activity
Parathyroids
regulate supply of calcium
Liver
Pancreas
Kidneys
Adrenals
glands of fight or flight
Gonads
sex glands

Endocrine Glands
- Pituitary
- Pineal
- Thyroid
- Thymus
- Adrenals
- Gonads

The endocrine glands, shown above, secrete hormones directly into the blood stream. Tiny amounts of hormones have a strong effect on the processes of the body. They regulate body growth and the rate at which the body uses food. They also help the body adjust to stimuli that might otherwise prevent it from functioning.

The Growing Body Goes Through Definite Changes In Developing the Characteristics of an Adult

The most rapid growth of the body takes place between twelve and sixteen years of age. This is when the age of adolescence begins. You might say that you grew 2½ inches each year between the ages of three and thirteen years. But the twelve-year-old girl's next three or four years growth will be more rapid until her adult height is reached.

Between the ages of twelve and sixteen, girls usually grow faster than boys. You will find many girls in class who are taller than boys. Boys usually grow more rapidly between the ages of fourteen and seventeen or eighteen, and at the end of this time, are usually taller than girls. Each person grows at a different rate, some developing earlier, and some developing later. You know as you grow taller you also increase in weight. As with height, the percentage increase in weight is greatest during the first three years of life, then slows down to a more uniform increment until the age of ten. The next four or five years see a rapid increase, followed by a slower, more even growth until one reaches adult size. The increase in weight of most organs, with the exception of the brain, is at the same rate as increase in weight of the rest of the body.

During the period of adolescence, many important changes take place in the body, both glandular and physical. Boys develop larger muscles and become better coordinated. At the same time girls develop into young women. The time adolescence starts is different in various boys and girls. All young people go through these changes sooner or later. The body is growing rapidly. The body is usually able to coordinate the muscles of the head first. The four main stages of growth in the body are infancy, childhood, adolescence, and adulthood.

STUDENT ACTIVITIES AND DEMONSTRATIONS

When students have health examinations, and are weighed and measured, they can make a chart which may show that growth is quite rapid during adolescence, from about 12-16 years of age.

The lack of development of muscular coordination, by children, is shown by the inability of first graders to thread a needle. An interesting comparison can be made between amounts of time that boys and girls require to thread a needle. As a student activity compare the height of boys and girls by selecting at random five girls and five boys of the same age in the class. Measure their heights and make a chart. Is the average height at this age greater for boys or for girls?

Reading Materials and Resources

Books

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CHAPTER IV

NUTRITION

Objectives

To learn about the sequence of enzymatic reactions, chemical reactions, and physical reactions that make up the process called digestion.

Food Requirements For Man's Survival

What are the main functions food perform?

Foods supply energy to keep our body warm (a constant average temperature of 98.6° F.) and to drive all the chemical reactions of metabolism and catabolism.

Food is used in all body functions. It supplies materials for growth and the repair of protoplasm as well as materials for manufacturing certain secretions such as digestive juices and hormones.

The six nutrients required by man are carbohydrates, fats and oils, proteins, minerals, vitamins, and water.

I. Carbohydrates are chemical compounds composed of carbon (C), hydrogen (H), and oxygen (O) in a ratio of two hydrogens to each oxygen atom with carbon atoms being often similar in number to oxygen atoms in a carbohydrate molecule.

1) Carbohydrates include the sugars and starches.

   a) Simple sugar (monosaccarides) are dextrose, fructose, galatose ($C_6H_{12}O_6$).

   b) Examples of double sugars (disaccarides) are sucrose (cane or common), maltose (formed from starch by amylase and ptyalin), and lactose (mild sugar).

All three have the same molecular formula ($C_{12}H_{22}O_{11}$).

c) Polysaccarides are built from a combination of three or more simple sugars.

2) Carbohydrates are sources of energy: Glucose, the sugars carried in the blood stream, is man's most important energy source. Generally speaking oxidation is the combining of a substance with oxygen (burning). When carbohydrates are combined with oxygen, energy is released.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + H_2O + \text{ENERGY}$$

The above reaction occurs in the mitochondria and the energy is generally either stored in the bonds of ATP or is given off to drive an energy requiring reaction which takes place simultaneously. Very little energy is lost as heat. Living things are far more efficient in the use of chemical energy than the most efficient internal combustion engine ever made. ATP is an immediate source of energy for living things. It yields energy for driving reactions not coupled with oxidation.

Some foods rich in carbohydrates are sugar, syrups, honey, molasses, potatoes, rice, bread, cereal, dry peas, beans, corn and carrots. These carbohydrates are reduced to simple sugars by hydrolysis during digestion.

II. Fats and oils are composed of the same chemical elements as carbohydrates but in different proportions. The hydrogen to oxygen ratio is much greater in fats. $C_{59}H_{110}O_6$ is a fat. Why eat fat?

1. Fats supply about twice as much energy as carbohydrates. Why?
2. Fats are carriers of vitamins, e. g., Vitamin A is found in butter.

Some foods rich in fats are bacon, butter, fat meat, cream, cheese, vegetable oils, nuts.

III. Proteins are large molecules containing at least the elements carbon, hydrogen, oxygen and nitrogen. Sometimes proteins contain sulphur, phosphorus, and iron. Proteins are used primarily for growth and repair but they can be broken down to be used for energy. Proteins are not stored in our body so we must eat them every day. If we don't use all out intake of protein it is converted into energy.

Amino acids are the building blocks of protein. Our digestive system breaks down proteins into amino acids which are absorbed. Ten amino acids are essential. These are the ones our body cannot manufacture so we must eat foods that supply them. There are 36 known amino acids. Our body can manufacture 26 of the 36 amino acids, which means that the remaining 10 amino acids must be included in our diet.

Plants can manufacture our essential amino acids.

A food especially rich in proteins or amino acids is milk, the most nearly perfect food. It contains 26 amino acids, 10 of which are essential. Most of the amino acid requirements could be obtained from drinking the following quantities of milk:

Children under 18------------------1 quart per day
18-40------------------------------3 glasses per day
over 40----------------------------1 quart per day
pregnant women---------------------1 quart per day

Lean meat, eggs, fish, nuts, cheese, poultry, peas, and beans are also rich in proteins and amino acids.

IV. Minerals are inorganic substances found in nature. Minerals are needed to help us develop various types of tissues; to regulate our body activities, and to aid in respiration and digestion.

The following elements are necessary for many forms of life:

1) C - Carbon
2) H - Hydrogen → We get in nearly every food
3) O - Oxygen
4) P - Phosphorus - milk, meat, cereal
5) K - Potassium
6) I - Iodine - sea food and iodized salt
7) N - Nitrogen - we get in protein
8) S - Sulfur
9) Ca- Calcium - milk, eggs, cheese
10) Fe- Iron - liver, beef, green vegetables
11) Mg- Magnesium - green vegetables
12) Na- Sodium
13) Cl- Chlorine → Salt
14) Cu- Copper - liver, green vegetables
15) Zn- Zinc
16) Co- Cobalt
17) Mn- Manganese

Funk has named some accessory food factors vitamins. Because a deficiency or excess of those chemical compounds, the early discovered ones were all amines caused disease, a small amount of each of these compounds was considered vital to the diet of man (from vita=life). When more of the fifteen vitamines now known were discovered it was found that these compounds were not all in the amino group of organic compounds so the "e" was removed from the original term to name today's vitamins.

Vitamins are chemicals which the body cannot synthesize but must have to maintain certain essential chemical reactions. Although vitamin deficiencies occur today (starving people, single food diets, isolated people, jr. high people living on chips, cokes and candy, and liquid-diet skid-row people) most people who eat well balanced meals regularly need not worry about vitamins.

Vitamins are fairly simple to very complex organic compounds. A few are listed below:

Fat Soluable
A D E K

Water Soluable
B-1 Thiamin
B-2 Riboflavin and Niacin
C Ascorbic acid
B_{12} Pantothenic acid
All B complex

The function of vitamins is largely that of a helper to certain enzymes. Without the vitamin the work of the enzyme is stopped and the chemical reaction normally catelyzed by the joint work of the vitamin and enzyme does not occur. Vitamin A protects epithelial tissue against infections and keeps eyes healthy. A deficiency of Vitamin A causes night blindness and infections. Vitamin A is found in foods such as butter, cheese, milk, egg yolk, carrots, green leafy vegetables, liver and fish oils.

Vitamin D has to be present for calcium and phosphorus to build bones. A deficiency of Vitamin D causes rickets. Vitamin D is found in fortified milk, eggs, liver oils, and can be produces by the assistance of ultra-violet light in sunshine.

Vitamin K is necessary for clotting of blood. A deficiency in Vitamin K causes people to become free bleeders. Vitamin K is produced in our intestines from leafy vegetables, liver, eggs, and tomatoes.

Vitamin C is needed to maintain tissue and to promote the healing processes. A lack of Vitamin C will cause scurvy (bleeding gums) bleeding under the skin, and stiff swollen joints.

V. Water

Over two thirds of our body weight is water. Water is used to: produce secretions; act as a solvent for nutrients; maintain body temperature; transport dissolved materials, and carry wastes from our body. Human beings need the equivalent of 6 to 8 glasses of water per day.

Most of our water comes from vegetables and fruits; drinks such as milk and soda water, soups, and the oxidation of glucose.

A balance of diet is attained when our diet contains the right amounts of each of the six basic nutrients:

Carbohydrates
Proteins
Fats
Water
Vitamins
Minerals

Food energy is measured in calories. A small calorie is the amount of heat required to raise 1 gram of water, which occupies 1 c. c., one degree centigrade. A large Calorie (Kilocalorie) is 1000 calories ie. 1,000 small calories.

HOW CAN I BUILD AND MAINTAIN A HEALTHY BODY?

1. Gaining understanding of how the body functions.

DIGESTION

How do we digest food?

EXPERIENCE 1a: What happens to carbohydrates in the mouth?

PROCEDURE: Have children hold a soda cracker (a common starch food) in their mouth until the taste changes.

QUESTIONS: What is the taste? (sweet)
What happened? (Ptyalin broke down starch to sugar.)

EXPERIENCE 1b: Does the starch disappear?
(A) With cracker and water in a test tube, add iodine after 20 minutes.
(B) With cracker, water and saliva in a test tube, add iodine after 20 minutes.

QUESTIONS: What happened? (A) turned blue, (B) doesn't. Why? (Iodine reacts with starch to form blue substance)

EXPERIENCE 1c: Is sugar present?

PROCEDURE: (A) With cracker and water in a test tube, add Benedict's solution and boil.

(B) With cracker, water, and saliva in a test tube, add Benedict's solution and boil.

QUESTIONS: What happened? (A) Unchanged, (B) Turns yellow or red. Why?

LECTURE INFORMATION: Six salivary glands secrete the starch-splitting enzyme ptyalin. The functions of the saliva are lubrication and partial digestion.

EXPERIENCE 2: How does food move from the mouth to the stomach? (Peristaltic action)

PROCEDURE: Slide a greased glass bead down a rubber hose.

QUESTIONS: What process does this illustrate? (Peristaltic action) Could we swallow while standing on our head?

LECTURE INFORMATION: Peristaltic action is used throughout the digestive tract to move material.

EXPERIENCE 3a: What happens to protein in the stomach?

PROCEDURE:

(A) Put boiled egg white in water. keep at 98°F for 48 hours.
(B) Put boiled egg white in water, add 2 drops HCl, keep at 98°F for 48 hours.
(C) Put boiled egg white in ½ test tube of water, add 2 drops HCl and a pinch of pepsin, keep at 98°F for 48 hours.

HINT: A chicken egg incubator could be used for temperature control.

QUESTION: What happened: (Egg surface is ragged in C) Why? (Partial digestion)

EXPERIENCE 3b: What happens to milk (a common protein) in the stomach?

PROCEDURE: Add rennin to milk.

QUESTIONS: What happens? (coagulates) Why? (alters charge on colloid)

LECTURE INFORMATION: Functions of stomach: mixing, sterilization, partial digestion.

Secretions: protein splitting-pepsin
milk curdling-rennin
fat splitting-lipase

acid balance-
sterilization- hydrochloric
iron liberation- acid
stomach protection-mucin

EXPERIENCE 4a: What happens to starch in the small intestine?

PROCEDURE: To cracker crumbs in a test tube, add basic extract of pancreatin and keep at 98°F for 24 hours, then boil with Benedict's solution.

QUESTIONS: What happened? (Turns yellow to red) Why? (Sugar is reduced)

EXPERIENCE 4b: What happens to oil in the small intestine?

PROCEDURE:
(A) Mix oil, soap, and water.
(B) Mix oil, bile (from spleen or untrimmed liver)
(C) Mix oil and water

QUESTIONS: What happens? (A & B mix; C doesn't) Why? (Bile and soap are emulsifiers)

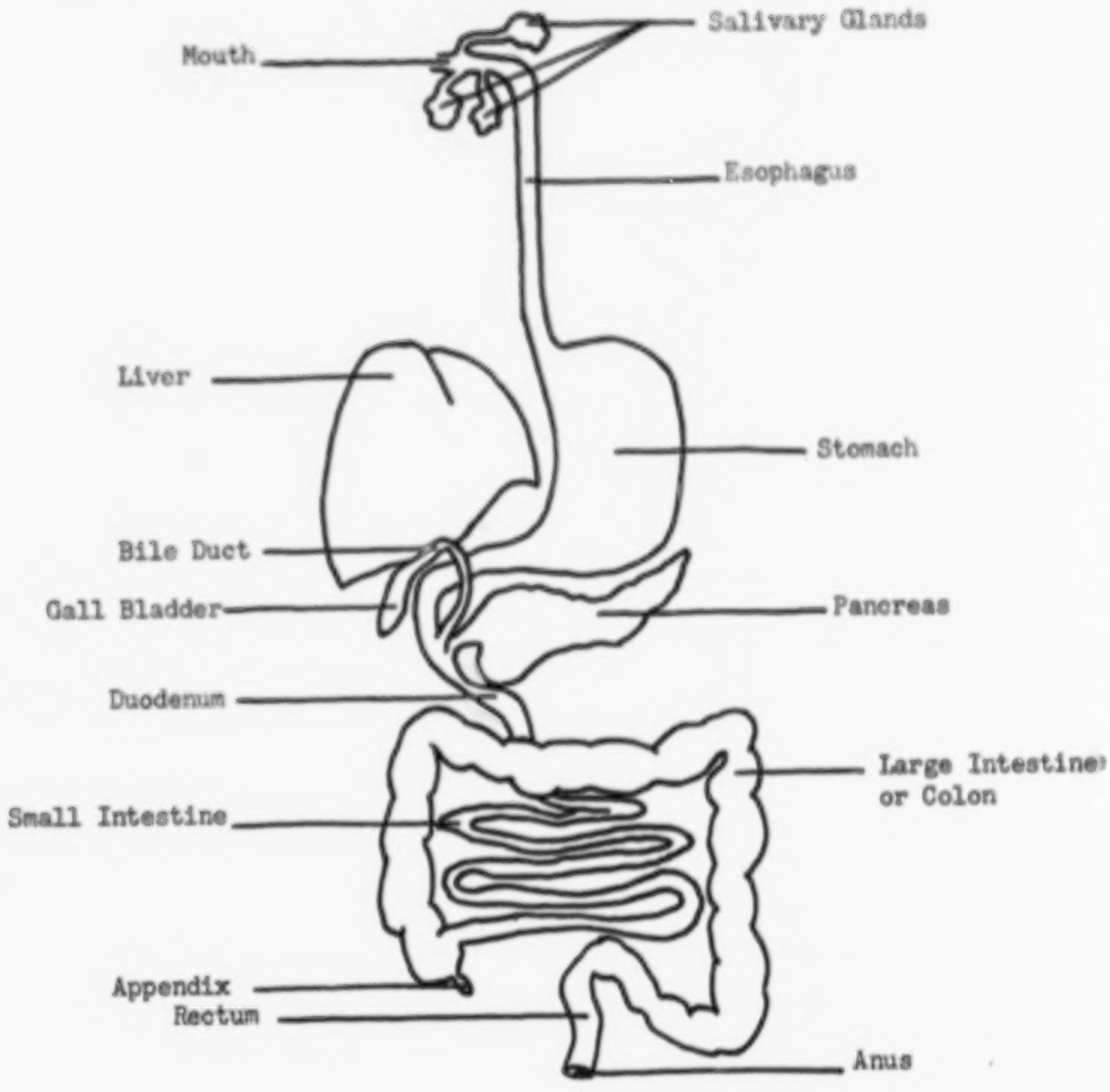
LECTURE INFORMATION: Review the parts of small intestine, the duodenum, the jejunum, and the ileum. (Use a "visible man" or plastic overlays or transparency overlays); explore the functions of the small intestine including completion of digestion and food absorbtion; describe the organs secreting into small intestine (i. e. the liver and the pancreas); Discuss the action of the secretions, bile-emulsifier, secretin-arouses, trypsin protein digestion, lipase-fat splitting, amylase-starch splitting. Explain how the undigested food is acted upon by bacteria which gives off important B vitamins; and describe the function of the large intestine in absorbing water.

EXPERIENCE 5: Examine untrimmed liver, esophagus, etc., from a chicken.

QUESTION: How are these similar to man's?

LECTURE INFORMATION: See drawing on following page.

DIGESTIVE SYSTEM


Salivary Glands
Mouth
Esophagus
Liver
Stomach
Bile Duct
Gall Bladder
Pancreas
Duodenum
Large Intestine or Colon
Small Intestine
Appendix
Rectum
Anus

References:

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Smith, and Lisonbee. *Your Biology.* (Second Edition) Unit 3, p. 110.

The Materials of Life. New York: Board of Education, 1962.

Refer to *How Can I Build and Maintain a Healthy Body* in this manuscript.

CIRCULATION

How does our blood circulate?

EXPERIENCE 1: Do "Harvey's vein blocking" exercise.

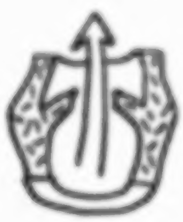
PROCEDURE: Place a rubber band around the forearm and stroke a distended vein (a) toward the heart (b) away from the heart.

QUESTIONS: What happens? (a) vein stays full (b) vein collapses until a branch is reached. Why? Valves in veins control flow.

What keeps the blood from pooling at the feet?

After passing through the capillaries, pressure from the heartbeat no longer pushes sufficiently to bring the blood back to the heart. Gravity adds to the problem.

(One-way valves in the veins and the squeezing action accompanying muscle tension or physical movement normally prevents blood pooling at the feet. Sometimes, however, the veins in the lower portion of the legs weaken causing some blood pooling and poorer circulation in the legs. This condition is present in what is called varicose veins.)



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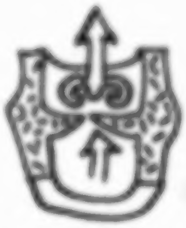
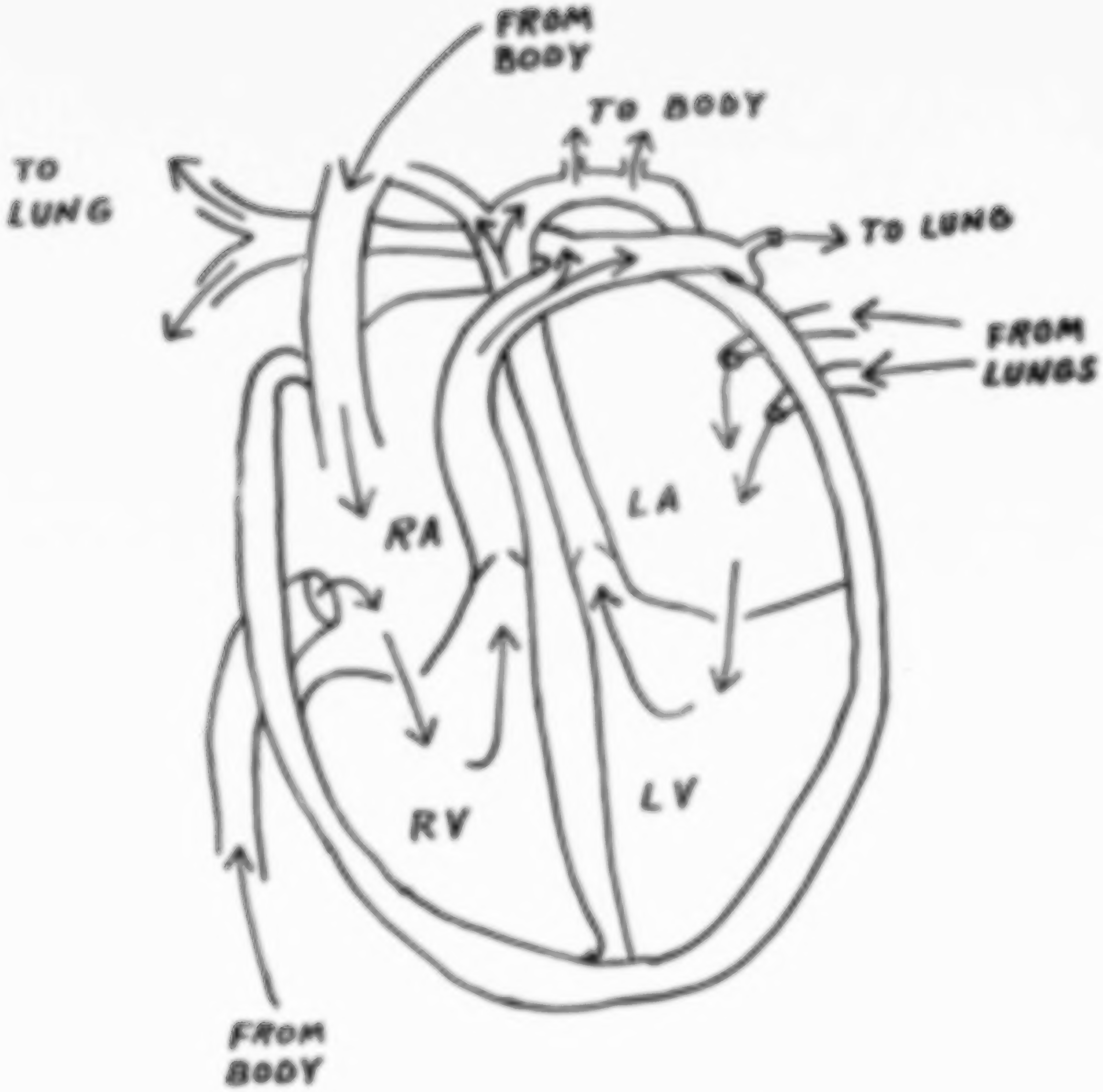
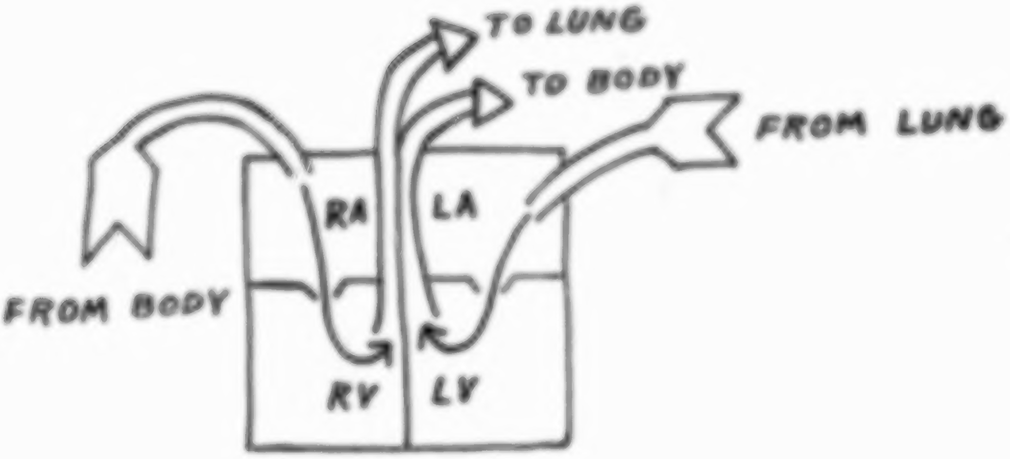


CLOSED

THE HEART


FROM BODY
TO BODY
TO LUNG
TO LUNG
FROM LUNGS
RA
LA
RV
LV
FROM BODY

CIRCULATION OF BLOOD THROUGH THE HEART


TO LUNG
TO BODY
FROM LUNG
RA
LA
FROM BODY
RV
LV

EXPERIENCE 2: Examine and dissect an untrimmed beef heart.

QUESTIONS: What is the path of the blood through the heart? (Blood always flows from the body to the right auricle of the heart, to the right ventricle, then through the lungs and back to the left auricle of the heart, through the left ventricle and out to the body.)
See drawing on previous page.

EXPERIENCE 3: Watch movement of red blood cells in web of frog's foot with a microscope.

PROCEDURE: Anesthesize a frog with ether, or inject 5 ml. of 1.1% urethan under the stomach skin or pith the frog. Wrap the frog in a wet paper towel and examin the web between the toes of one foot under the microscope. Look for small blood vessels showing moving blood.

ELIMINATION

1. Examine an untrimmed pig's kidney with bladder attached.

Body must get rid of wastes:

(1) CO_2 and H_2O

(2) Urea and salts; dead cells and bacteria

(3) Intestinal wastes

Gaseous wastes are removed by the lungs and liquid wastes are removed by the skin and excretory system.

(1) Light a candle. Recall how carbon and hydrogen of the candle unite with oxygen of the air to produce carbon dioxide and water vapor. Explain that heat and light energy are produced as the useful products. The waste products, carbon dioxide and water, escape into the air.

The body carries on a similar process in the form of this equation:

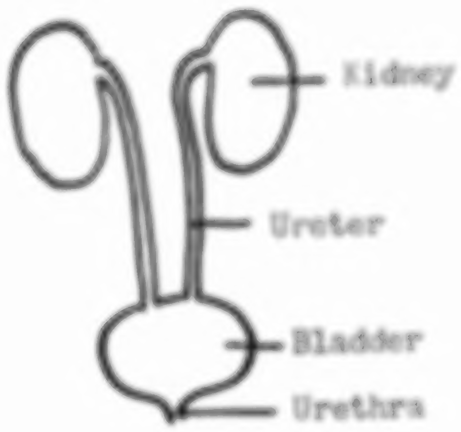
$$C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O + \text{ENERGY} \quad \text{(unbalanced)}$$

This process is known as oxidation. The energy is used by the body but CO_2 and H_2O must be excreted as gaseous wastes by the lungs.

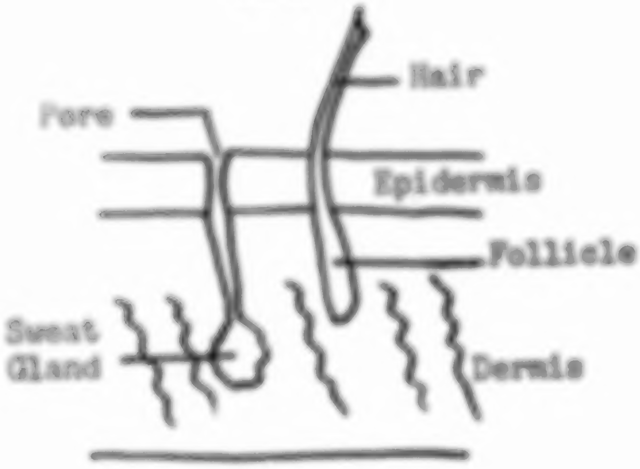
The living cells all over the body burn glucose. Complete oxidation of glucose yields water and carbon dioxide. These products are carried by the blood stream to the lungs.

(2) To get glucose out of proteins, your body must first change proteins to amino acids. From these compounds the liver takes out urea. Your kidneys excrete most of the urea and some water. A little urea and some water and salts leave your body through your skin. (Urea, a constituent of liquid wastes is produced by the breakdown of protein.) Activity: Show how perspiration may be useful. Dab some alcohol on the students' arms. Have them explain how the evaporation of sweat cools the body. Evaporation removes heat from the body, thus cooling it.

EXRETORY SYSTEM



SKIN



RESPIRATION

Objectives

To gain an understanding of the respiratory system and how it functions. To learn the difference between breathing and respiration.

Questions and Answers:

Q) What is the difference in breathing and respiration?

A) Breathing is taking air into the lungs and exhaling air from the lungs. Respiration is the process whereby energy is released to the cells.

Q) Where does "Respiration" occur?

A) In all living cells.

Q) Where does breathing occur?

A) In the lungs.

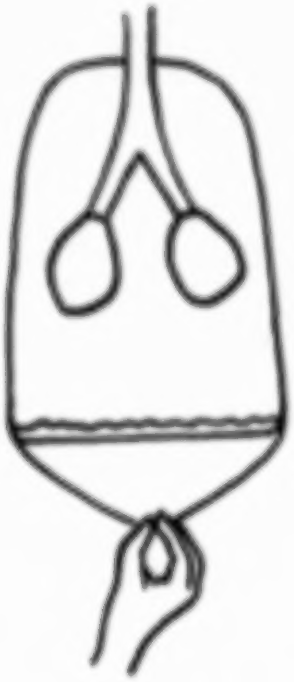
Q) How is oxygen transported to the cells from the lungs.

A) It is combined with hemoglobin to form oxyhemoglobin in the bloodstream and carried to the cells by the blood.

Experiences:

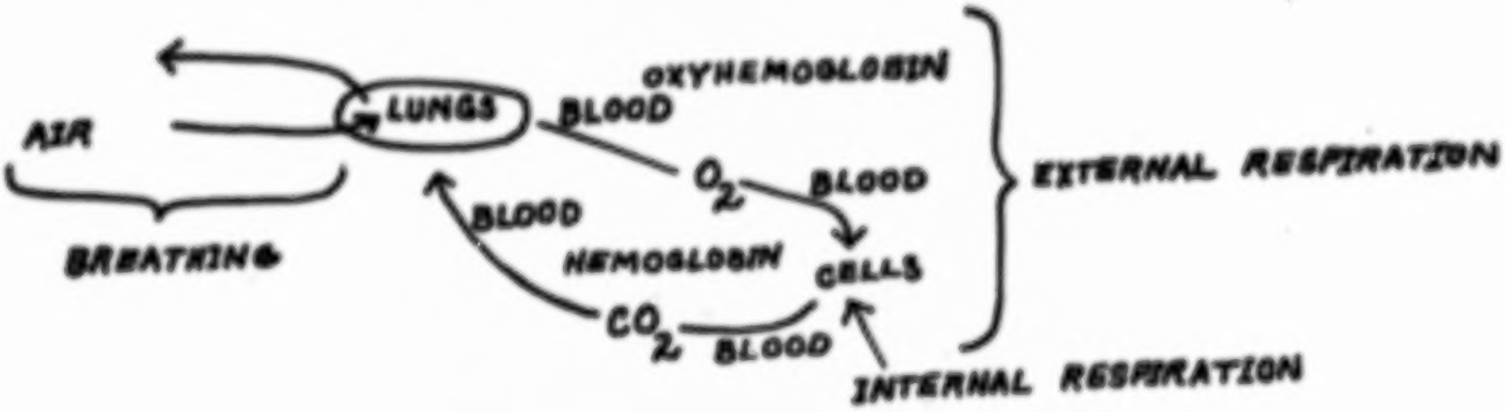
1. Remove the capillary tip of a chemistry wash bottle, remove the stopper and fill the bottle to overflowing with water. Replace the stopper and blow a breath full of air into the bottle from the end that held the capillary tip. Measure the displaced air by refilling the wash bottle from a graduated cylinder with a maximum measure of water in it and subtract when you are finished. What aspect of lung capacity does this measure? (Volume of intake above latent level)
2. Examine pig or frog lungs that have been inflated. Insert a glass tube in the trachea opening and tie a string around the trachea where the glass tubing enters, blow the lungs to capacity and note the difference in volume.
3. Mechanics of breathing: Insert a glass y-tube into a rubber stopper which fits into the top of a bell jar. Fasten the balloons of the same size by means of rubber bands to the two arms of the y-tube. Cut a circle of thin rubber sheeting large enough to fit over the bottom of the bell jar and tie it in place. Cut a small hole in the

center of the rubber sheeting and insert a cork and tie it down as a holdfast. Check to see that there are no leaks in the sheeting. The balloons represent the lungs and the rubber sheeting represents the diaphragm. When the students pull or push the diaphragm, a change takes place in the size of the balloon lungs. (Be sure to blow up the balloons to nearly full expansion and let all the air out to prestretch them before beginning.)



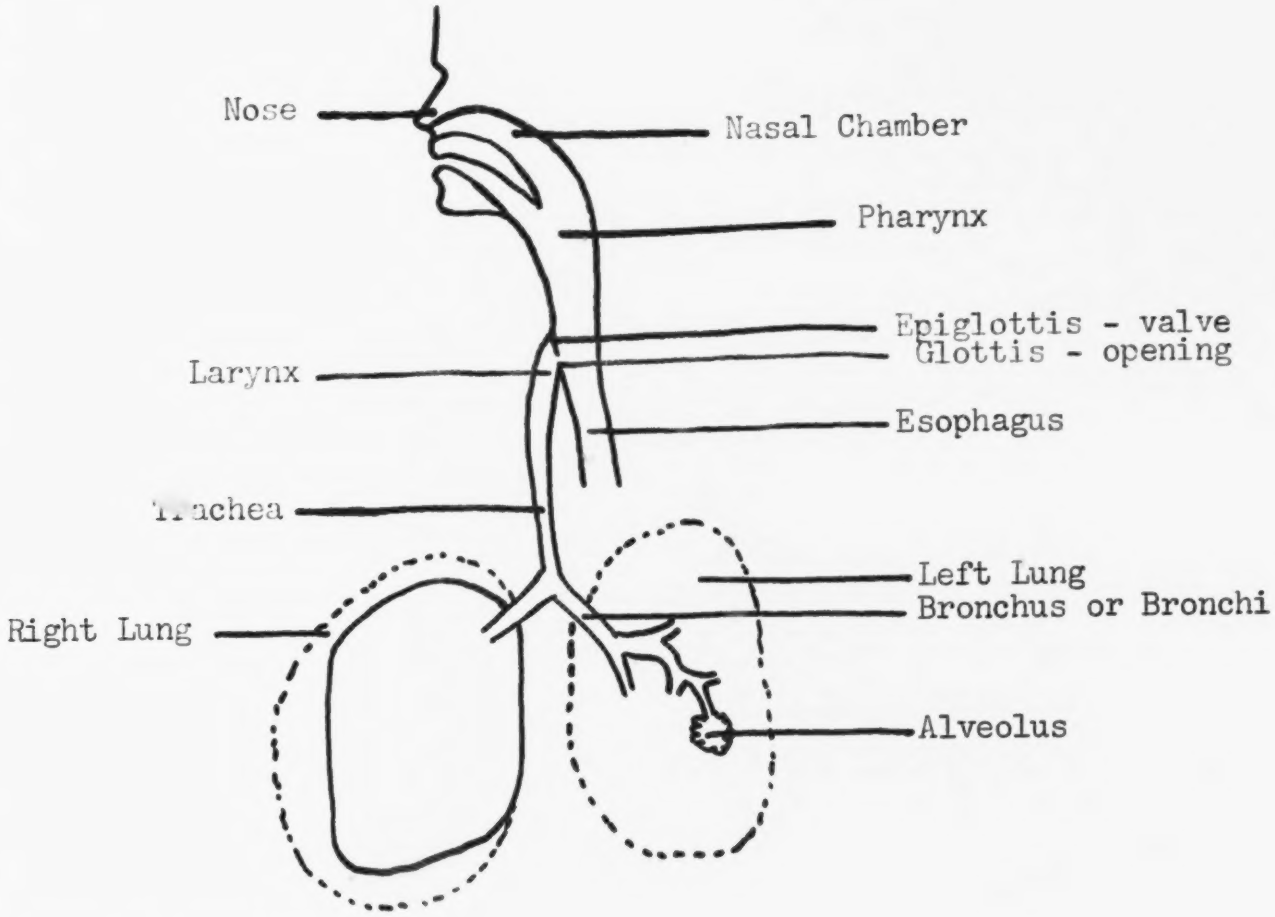
Respiration: Process by which energy is released in the cell.

Breathing: Inhaling or taking air into the lungs and exhaling.


OXYHEMOGLOBIN
AIR
LUNGS
BLOOD
O_2
BLOOD
EXTERNAL RESPIRATION
BLOOD
BREATHING
HEMOGLOBIN
CELLS
CO_2
BLOOD
INTERNAL RESPIRATION

The process of breathing and taking in O_2.

1. Inhaling - taking air in
2. Exhaling - giving air out


Nose
Nasal Chamber
Pharynx
Epiglottis - valve
Glottis - opening
Larynx
Esophagus
Trachea
Left Lung
Bronchus or Bronchi
Right Lung
Alveolus

Other uses of respiratory system:

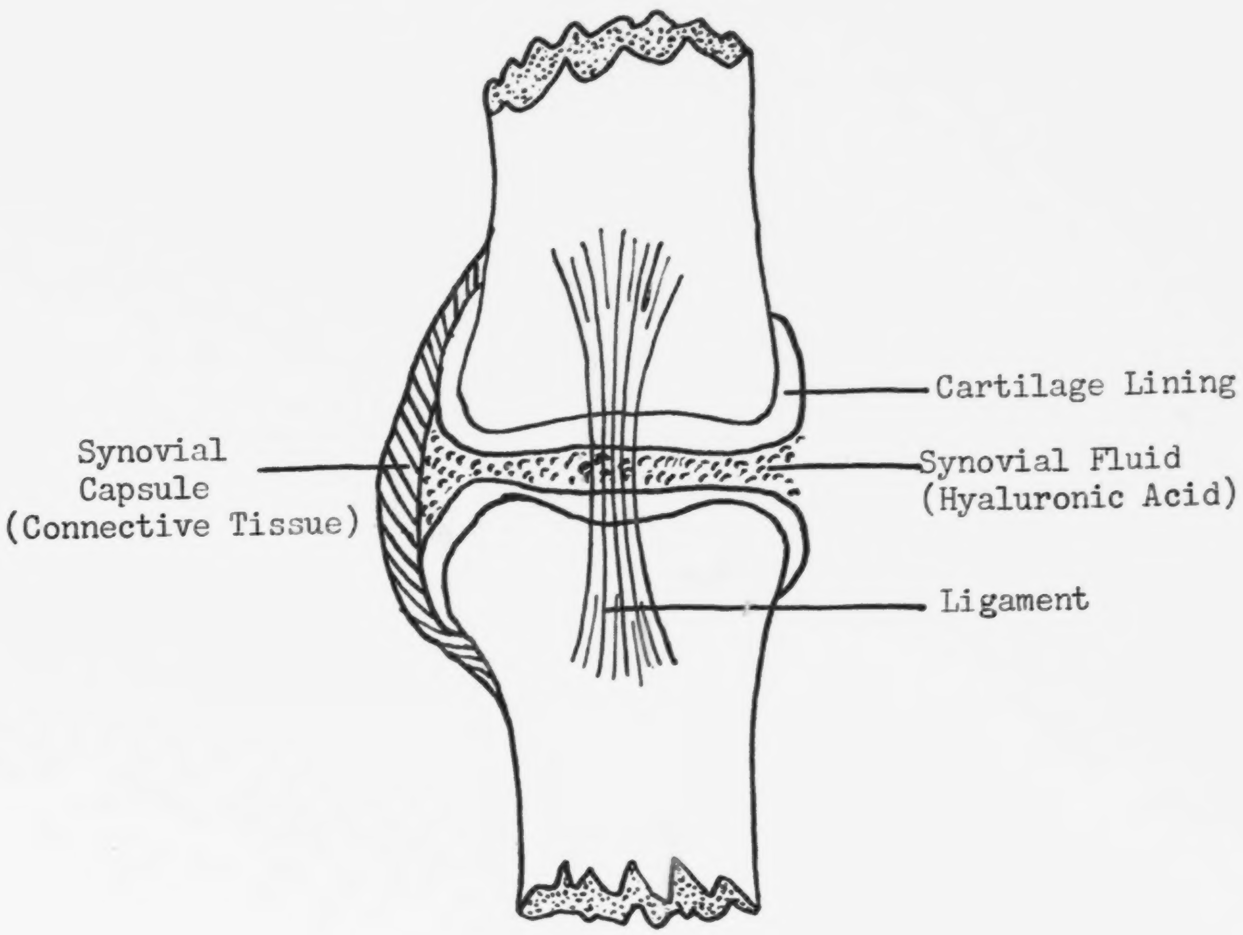
1) Speaking
2) Coughing
3) Straining

SKELETAL AND MUSCULAR SYSTEMS

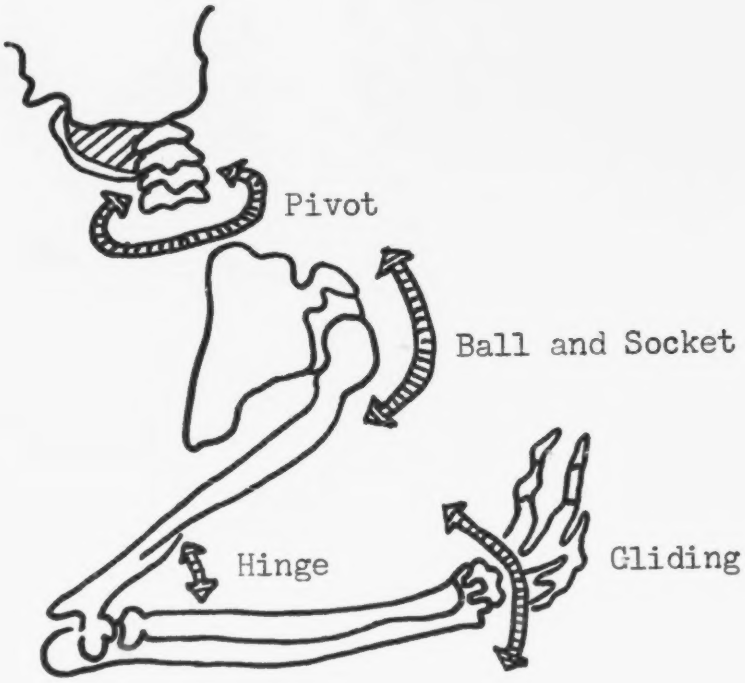
Objective

To understand the function of the body's framework.

Examine and dissect a frog's leg, noting the juxtaposition of the muscle insertions and the leverage systems.


Cartilage Lining
Synovial Capsule (Connective Tissue)
Synovial Fluid (Hyaluronic Acid)
Ligament

TYPICAL JOINT UNIT


Pivot
Ball and Socket
Hinge
Gliding

TYPICAL JOINT TYPES

NERVOUS SYSTEM

Examine the following phenomena by classroom experimentation:

1. Cold points vs. pain points vs. pressure
2. Hearing distance
3. Nerve spacing with two pins
4. Color vision tests
5. Taste areas on tongue
6. Overlapping of taste and smell by eating an apple but smelling a pear while blindfolded. Repeat asking the subject to hold nose and ask him to identify a tiny piece of apple and a tiny piece of onion. (Should be about the same showing the effect of smell on flavor.)

Objectives

To find out how my skin protects me. To gain knowledge about the structure of the skin. To explore the function of perspiration.

The structure of the outer covering of man is divided into two main regions: (1) Epidermis - surface layer of dead transparent cells and (2) Dermis - living tissue which contains nerve endings, glands, and blood vessels. Beneath the dermis is the connective tissue containing subcutaneous fat.

The cells at the base of the epidermis are living and are constantly multiplying and pushing to the top. When they pass the blood supply they quickly die and are sluffed off. This constant wearing away takes place more rapidly where there is more friction.

The skin protects against ultraviolet light damage to deeper tissues. Other animals either have a thick covering or utilize nature as a protection against the ultraviolet rays. The human skin is equipped with the capacity to form pigments which can absorb ultraviolet light.

The skin takes the beating of ordinary living. It keeps moisture and bacteria out of the body.

The skin acts as a wide heat radiating surface. The internal organs contribute a great deal of heat and the circulatory system distributes it to the dermis where it is radiated away from the body.

The evaporation of a liquid requires heat energy.

The skin uses this principle to cool our bodies. In order for a drop of water (liquid form) to change to water vapor (gaseous form) it must absorb its heat of vaporization. Perspiration absorbs heat from our skin to reach the heat of vaporization for the water within it and this water evaporates into water vapor. The effect is to cool our bodies except when the air is so saturated with water vapor that it can hold no more. The main body of the sweat gland is located in the dermis. Here the perspiration is collected and sent via a coiled tube to the surface through the pore. When evaporation takes place, the body is cooled. When sweat remains on our body we are in some danger of overheating. Do the palms of your hands sweat much? (yes)

Follow Through Activity:

1. Investigate the usefulness of hair glands in the skin.
2. Investigate skin injuries and healing processes.
3. Investigate nerve endings in skin and their function in protection.
4. Investigate pigmentation in the skin.

THE FEMALE REPRODUCTIVE SYSTEM

Objectives

What organs make up the female reproductive system and what is the function of each?

The Ovaries - The reproductive organs of the female produce the eggs or ova. Eggs (ova) are the female sex cells which when fertilized will produce a new individual.

Inside the ovary which is about the size of an unshelled almond, there may be found many egg cells in various stages of maturity. Even at birth a female will have these unripened eggs called follicles. As the female grows and reaches puberty the egg cells will begin to ripen one by one, and at intervals of about 28 days a mature egg will burst out of the ovary. This process is called ovulation. Ovulation occurs every three to five weeks, with 28 days as the average. As the egg leaves the ovary it passes into the Fallopian tubes.

The Oviduct or Fallopian Tube - The tube leading from the ovary to the uterus.

The anterior end of this tube is funnel shaped and partly encloses the ovary. The ripened egg follicle falls from the ovary into the oviduct and is carried to the uterus. Fertilization usually occurs in the oviduct, but sometimes in the uterus. The fertilizes egg is called a zygote.

The Uterus - A thick-walled organ with many blood vessels. It is the structure between the vagina and the oviduct.

The egg will pass from the oviduct and into the uterus. If it is fertilized by the male sperm, it will attach itself to the wall of the uterus and start to grow and develop. With the help of the uterus it will contain the developing embryo and will break at birth to release the fetus. When the zygot becomes imbedded in the wall of the uterus a group of cells in the wall of the uterus becomes specialized as an exchanging organ (the placenta) between the blood system of the mother and that of the developing embryo. Following the baby's birth the placenta, tied to the baby by the umbilical cord, detaches from the wall of the uterus and is expelled from the mother as the "afterbirth."

The Embryo - The developing young during the first eight weeks of pregnancy.

The Fetus - The developing young for the last seven months of pregnancy. We call it a fetus until birth.

The blood vessels of the mother come in close contact with those in the placenta. Food and oxygen diffuse from the bloodstream of the mother into the bloodstream of the fetus, and wastes diffuse from the fetus back to the mother's bloodstream. The bloodstreams of the fetus and the mother are not connected. If the egg is not fertilized when it reaches the uterus it will remain there and prepare for pregnancy. If not fertilized in the uterus within about 30 hours the egg will disintegrate, and all the preparations for pregnancy will be shed by the body.

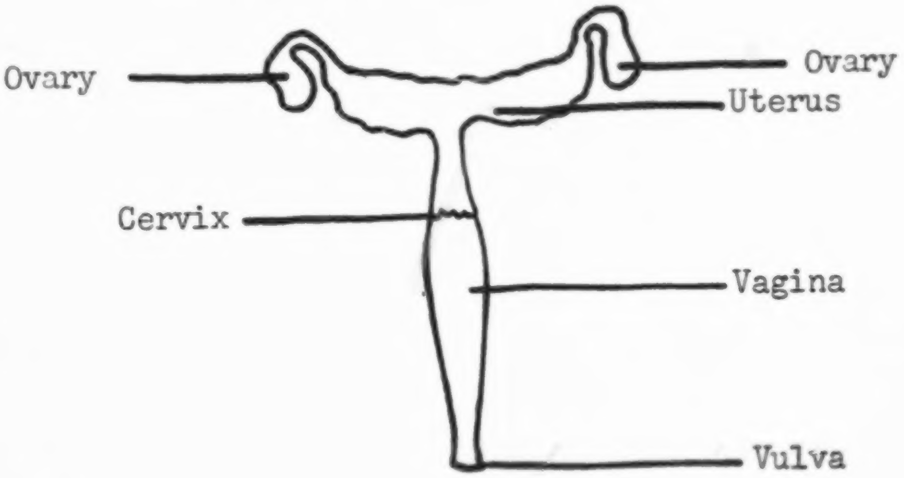
Some of it will be absorbed. The larger blood vessels will break when this shedding occurs and will sometimes cause pain. The blood will pass out the vagina along with some of the dissolved membrane. This shedding of the lining of the uterus is called menstruation. The whole occurrence involving the release of the egg from the ovary, bodily preparations for pregnancy, and its release from the body is called the menstrual cycle.

The Cervix - The neck of the uterus which makes a fold. This is the opening from the vagina to the uterus.

The Vagina - Tube leading from the uterus to the outside of the body.

The sperms from the male are placed in the vagina during sexual intercourse. They then swim through the cervix and up the uterus. If an egg is present either in the oviduct or the uterus a sperm will combine with it to form a zygote.

In the vagina near the outside opening (vulva) there is a membrane called the hymen. It is usually broken during the first sexual intercourse, but not always. Sometimes the hymen is broken during physical activity such as a fall when playing ball, etc.



THE MALE REPRODUCTIVE SYSTEM

Reproduction takes place with the union of sperm and egg which determines the generic characteristics of the embryo.

The sperm originates by fission of the cella forming the lining of the convoluted seminiferous tubules (see next Figure 1). Approximately 800 of these two-foot long tubules fill the interior of each of two testicles, which are suspended between the thighs in a pouch called the scrotum (see Figure 2). This scrotal sac exposes the testicles to a temperature of a few degrees below that of the body cavity, which is apparently essential for the proper development of the sperm.

The sperm consist of a "head", which contains the chromosomes for future development, which is about 4 microns long, and a "tail", whose whip-like motions provide locomotion, which is about 150 microns long.

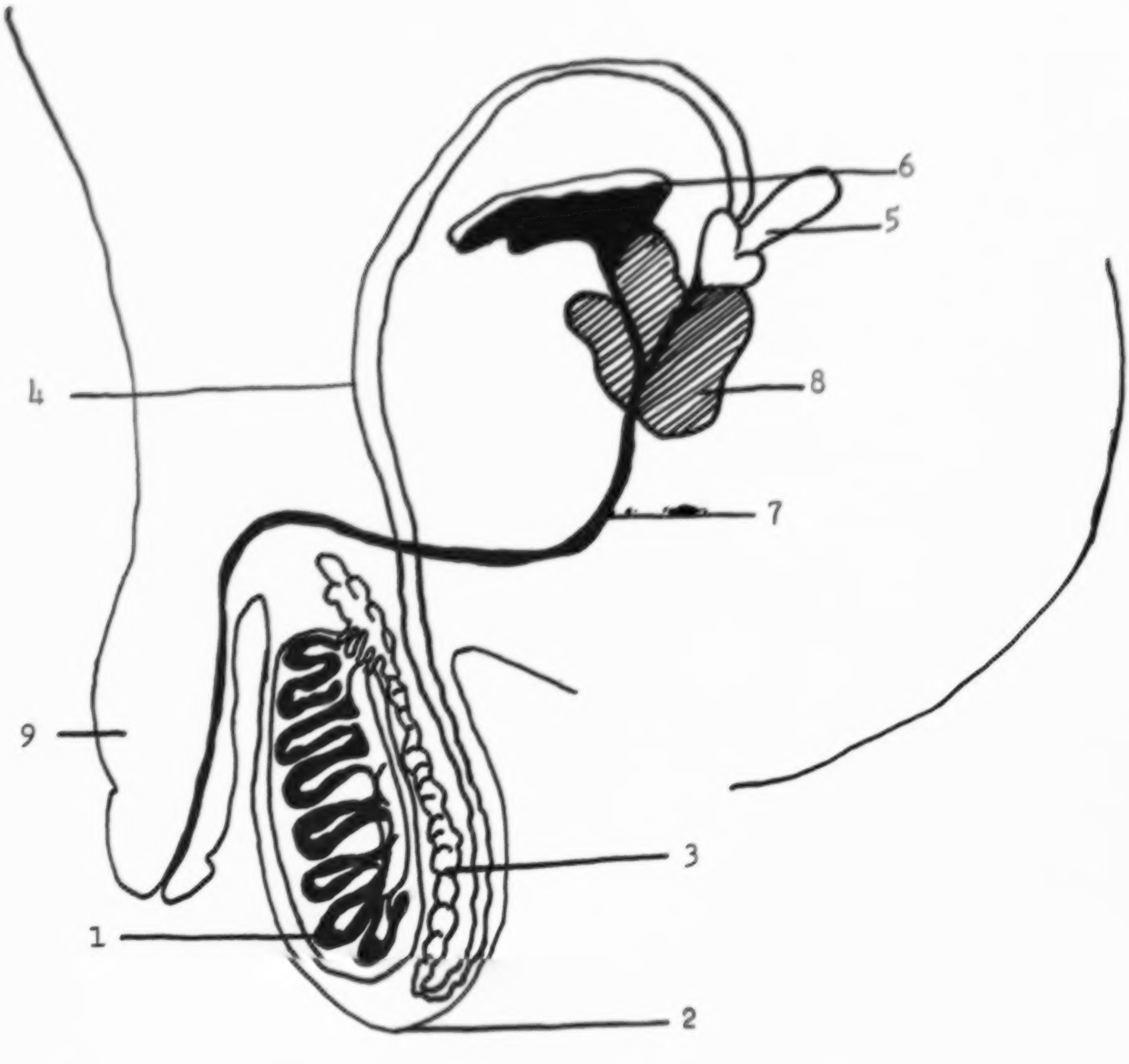
The seminal cells are moved from the testicles to the epididymis (see Figure 3), where they will gain the ability to move themselves. They are moved in the epididymis by cilia and peristaltic action through the vas deferens (see Figure 4), to the seminal vesicles (see Figure 5) which are behind the neck of the bladder (see Figure 6).

The seminal vesicles which drain into the urethra (see Figure 7) secrete a sticky fluid which provides an aqueous medium in which the sperm may swim.

Surrounding the urethra is a large, heart-shaped organ called the prostrate gland (see Figure 8), secretes a basic fluid permitting mobility of the sperm, neutralizing the acid of the vaginal vault, and providing lubrication for insertion of the copulatory organ.

As it is necessary for the male to deposit the sperm cells and fluid deep within the reproductive organ of the female, the male has developed a copulatory organ, the penis, which can be inserted into the female. With the proper stimulus, the arteries which bring blood to the penis enlarge, and the veins which drain blood from the penis are constricted. This causes the penis (see Figure 9), which normally is about four inches long, to become erect, hard and stiff about six inches long.

THE MALE REPRODUCTIVE SYSTEM



1. Convoluted Seminiferous Tubules
2. Scrotum
3. Epididymis
4. Vas Deferens
5. Seminal Vesicles
6. Bladder
7. Urethra
8. Prostrate Gland
9. Penis

This erect penis, in copulation, is placed within the female vagina. The tactile excitation of the sensitive tip of the organ, in contact with the walls of the vagina causes a series of muscular contractions, called the "orgasm" which initiates a peristaltic action beginning in the testicles and moving along the epididymis and vas deferens, driving about four millimeters of sperm cells and seminal fluid foward and shooting them out of the urethral opening into the vagina. This process is called "ejaculation."

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CHAPTER V

WHAT CAUSES ME TO BEHAVE THE WAY I DO?

During the last two or three decades, educators have become convinced that effective teaching and learning are best carried out when the various growth patterns of the individual are recognized. Within these total patterns of growth, there are aspects concerned with the physical, social, emotional, intellectual, and moral growth that demand the attention of the educator. Growth and development are different for each individual, and various aspects may develop at differing rates in the same individual.

Since it is known that children develop at varying rates, children who mature more or less rapidly than would be expected must be provided with experiences suitable to their own rate of growth and development. This leads to the need to differentiate programs and instruction at each level.

Self-Concept-----Positive or negative in regard to worth.

Aims for this section: Students should be led to an awareness of the many ways in which positive attitudes contribute to further personality growth, and how negative attitudes may hinder this development. Personality comes from the "inner you" and manifests itself in the "outer you."

Personality is that which makes you an individual, different from everyone else. It includes your body; the way it looks, functions, and grows. It includes your intelligence, emotions, habits, and attitudes that make you act as you do. Further, it is the result of all your experiences; the people you know, the things you do, the subjects you study at school, and the way you handle your problems. In short, your personality is you and your concepts of yourself. Whether they are positive or negative, plays a most important part in the formation and maintenance of you as a well adjusted person.

Are you well adjusted emotionally?

Test yourself with this check guide.

A. Are you free of inner conflicts?

B. Do you apply your intelligence to effective solutions to the problems of living?

C. Do you recognize the reality and inevitability of conditions to which you must adjust?

D. Do you have self control, and yet retain ability to freely express a certain amount of emotional expressions?

E. Do you enjoy social contacts and interests? Is your world a friendly place, peopled by pleasant people?

F. Is your personality consistent?

G. Are the goals you accept reasonable and within reach of your tastes and capacities?

H. Do you have adequate drive based on good physical and mental health?

Good adjustment at adolescence requires:

A. That the individual be happy, contented, and relatively free from anxiety and stress.

B. That your society accepts and evaluates you as competent and as conforming reasonably well to conventional conduct.

C. A developing ability to tolerate frustration and to adjust to problems and different situations you may encounter.

A short check which may give you more information about your personality, your concepts, and the way others see you is given below:

A. Can you take defeat?

Which of these is your reaction after a tight ball game which you lost?

This	Or	This
The referee was unfair. He didn't catch the other team's fouls, but he called all of ours.		Well, we played our best, but they just outplayed us.

B. How do you take misfortune?

An important game is coming up tomorrow and one of your star players is ill.

Is This You?	Or	This?
Just our luck, our biggest game, and with Joe out, we can't possibly win.		Bad luck, but even with Joe out, Tom will be in there doing his best and I think we'll be in there helping.

C. After a hard campaign for a school office, you lose by a large margin.

Is This You?	Or	This?
Congratulations Jack! It was a nice race, and I enjoyed it even if I did lose. If I can help you in any way, call on me.		I don't care. They voted for Jack because he has a nice car and lots of money to spend.

D. Tryouts for the Christmas play are tomorrow.

Is This You?	Or	This?
I'd like to be in the play but I don't stand a chance. There's no use in me going to the tryouts.		I'm going to try. This will be fun whether I get the part or not.

You can make many of these self-help study situations in your class. Each of them will be an informal way for you to determine whether you have a positive or a negative outlook on life, and in discussing the results, you will gain much experience in learning to mold yourself a better personality. Just remember, everyone has problems. They just have different ways of reacting to them. It's all up to you!

CHARACTERISTICS: JUNIOR HIGH

(Ages 12 through 14)
(Grades 7 through 9)

Physical	Social	Emotional	Intellectual
1. Allergies can manifest themselves fairly commonly.	1. Sometimes act ashamed of their family and home background.	1. The development of an anxiety neurosis happens on a relatively frequent basis.	1. Begin to think of economic independence and future plans during this period.
2. Have a voracious appetite or are "picky" in their food habits.	2. Have a tendency to copy less desirable adult behaviors.	2. Demonstrate less responsibility due to a fear of failure.	2. Have an inclination to ignore adult help in planning.
3. Commonly munch between meals.	3. Careless in language and work.	3. Moody.	3. Intrigued by mechanical gadgets.

Physical	Social	Emotional	Intellectual
4. Blushing common due to changes in vasomotor system.	4. Slavic to gangs.	4. Unstable and restless.	4. Never begin things soon enough. At odds with time.
5. Usually experence good health during adolescence.	5. Frequently assume affectations.	5. Become more adept at self-assertions.	5. Easily distracted: skip from subject, and demonstrate difficulty in concentration.
6. Permanent teeth complete their eruption with the exception of the wisdom teeth.	6. Develop more ability to cooperate with others.	6. Are unusually confidential at times.	6. Creative powers seem to fluctuate.
7. Boys reach sexual maturity one or two years later than girls.	7. Disguise feelings toward family.	7. Boys are very disturbed if they manifest effeminate characteristics.	7. Enjoy working with concrete materials.
8. Indicate uncertainty with respect to bodies by being self-conscious and displaying eccentricities in posture and gait.	8. Adopt fads and extremes in their dress, speech, handwriting, and mannerisms.	8. Show anxiety & conflict over their appearance of secondary sex characteristics.	8. Much energy spend in fantasies.

Physical	Social	Emotional	Intellectual
9. Individuals arrive at adolescence at various ages and develop toward maturity at different rates.	9. Heated rivalries between siblings develop and disappear again and again.	9. Display feelings of persecution.	9. Undergo a steady widening and deepening of their capacity to think and reason.
10. Overall body development is not steady and may contribute to nail-biting, stammering, and uncoordinated behavior.	10. Like to participate in rituals.	10. Show evidence of strong superstitions.	10. Exhibit listlessness due to rapid physical growth.
11. Physical growth is often so rapid it results in awkwardness.	11. When boy-girl groups are formed for recreation the boys are more reluctant to join in.	11. If maturation differs from group average, have feelings of inadequacy.	11. Those who depart to any marked degree from average in development make little progress in school.
12. Develop a lack of balance between bones, muscle, heart, and lungs.	12. Congregate and play in organized groups.	12. Pressure to succeed is felt keenly. They may even use dishonest methods to win recognition.	12. Their interest in abstractions is at a low ebb.

Physical	Social	Emotional	Intellectual
13. Girls are likely to be taller, heavier, and more developed physically, mentally, and socially than the average boy of the same age.	13. Resent being teased and find their friend's criticism hard to take.	13. Are subject to crushes.	13. The criticism given by their teachers is interpreted as an expression of personal feelings against them.
14. Get tired easily but don't want to admit it.	14. Display drastic behavior; daring, aggressive, critical, boisterous, argumentative, rough-and-ready, defiant, less obedient, rebellious, run away from home, or docile to family.	14. Develop a new inward looking interest in their own bodies and personalities.	
	15. Demonstrate extreme devotion to a particular boy or girl friend, but are likely to transfer the devotion to a new friend overnight.	15. For boys-overt homosexual practices are common, while such activities are rare in girls.	
	16. Experiment with many new experiences.	16. Use fantasies.	
	17. Begin to withdraw from the family.	17. Are concerned about the "future."	

Physical	Social	Emotional	Intellectual
		18. Develop a sophistication which is displayed in conversation.	
		19. Isolate themselves more often.	
		20. Start to devaluate parents and turn to other adults.	

NEEDS: JUNIOR HIGH

(Ages 12 through 14)
(Grades 7 through 9)

Physical	Social	Emotional	Intellectual
1. Adequate nutrition.	1. Peer acceptance and approval.	1. Deeper understanding of cultural heritage.	1. Accurate physiological information regarding the growth processes and sexual development of their body and for the opposite sex and sexual union.

Physical	Social	Emotional	Intellectual
2. Usually require eight or ten hours of sleep.	2. Intense friendships.	2. Security in the orientation to adult behavior.	2. Ways of making use of natural energy, vivacity, and imagination.
3. Regular exercise and activity, preferably in open air.	3. To belong to organized groups or cliques to which they may give loyalty.	3. Understanding of their vacillating affections.	3. Guidance in how to study and how to plan a day's activity.
4. An organized physical education program.	4. Find their pragmatic role in groups; for status comfort.	4. Find self-direction.	4. Unobtrusive guidance by adults.
5. Physical and dental check-up and correction of defects at regular intervals.	5. Emancipation from their family.	5. Earn money of their own.	5. Procedure on how to find a job.
	6. Share knowledge and experience with close friends.	6. Experience success.	6. Learn by handling, doing, observing; need concrete illustrations.
	7. Security and understanding from his home.	7. Protect personal integrity.	7. Greater share in planning.
		8. Make inner strivings match reality.	8. Longer time to complete jobs.

Physical	Social	Emotional	Intellectual
		9. Dissipate feelings of guilt connected with thoughts about physiological changes.	9. Recognition of individual differences in capabilities of others.
		10. Broader interests and appreciations.	10. Preparing and training for a job or career.
			11. Develop ability to concentrate and increase his attention span.

FEELINGS---

Objectives

A. To become aware of the different causes for the way I feel. (physiological and psychological)

B. Show students that it is possible to be unaware of the basis of their feelings or emotions. Also point out that they can be unaware of the reasons for various feelings or emotions.

Feelings involve emotions. I may or may not be aware of their causes. Behavior choices are influenced by a complex interaction of many factors.

1. We have read so far that an individual's awareness of his identity as a person and his judgment of his personal worth and value system is known as his self-concept. This self-concept is a continuing

awareness and evaluation depending to a large degree on previous mind-set interpretations and conclusions. However, experiences of success or failure and evaluations by others sometimes are given considerable weight to the continuing evaluation. A pattern of behavior could be said to repeat like-behavior which proved successful in the past while avoiding behavior which proved unsuccessful in the past. With all their shortcomings, man's learnings have been the reason for men's dominance over all other animals and his success in his battle for survival.

2. Psychological and social cravings, which are shaped in part by the nurturing society or culture, hold sway in individual behavior towards social approval. This is expressed in personal influence, power of authority, or prestige, freedom from fear, love and affection, curiosity and mental activity, need for personal achievements, and the physical presence of other people.

3. Another aspect of man's mental processes that has helped in his struggle for survival has been his emotions. What are emotions? We may say that an emotion is a reaction to a symbol or an external stimulus significant to the person involved rather than a reaction to the individual's own tissue needs. Is a reaction that moves us an emotion? Is the way we feel an expression of an emotion? Life without emotion would be life without motion, since the term emotion means to be moved. At times we feel moved to be happy, moved to anger, deeply moved or excited, or moved by fear. Conscious feeling is undoubtedly a part of emotions and yet emotions themselves may trigger unconscious psychological reactions.

When a person is emotionally aroused certain changes take place that may or may not be apparent to others or to the person himself. When the emotional experience is relatively clear, it usually involves feeling (such as the feeling of fear), impulse (such as an impulse to flee), and a perception of what it is that gives rise, or seems to give rise, to the emotion. Sometimes these elements of the experience are so vague that a person cannot describe the fear, and yet from his point of view they are very real. Impulses, feelings, and perceptions may be clouded and ambiguous that a person has no clear notion of what is happening to him or why he feels as he does.

Emotion is a part of the organizing processes of the growing child. Emotions serve a definite purpose in the striving of the individual toward self-realization.

Each child, because of the uniqueness of his organism and his experience, evolves to some degree his own methods for dealing with tension, frustration, fear, and other unpleasant feelings.

Our subjective feelings are often accompanied by characteristic actions and physiological changes. A feeling which is normally accompanied by characteristic behavioral and physiological events is an emotion. Three feelings that fall within the category of emotion are fear, anger, and euphoria.

Fear-Fear is the feeling associated with expectancies of unpleasantness. This may involve an expectancy of actual pain or it may involve an expectancy of distress of another sort, like a fear of failure or a fear of loneliness. Sometimes the basis of a fear is not understood by the person. Then we call the fear anxiety.

Any great discrepancy between what an individual expects and what actually occurs seems to produce fear. The most prevalent source of human fear seems to depend on learned expectancies of pain or distress. At times the fear--the learned expectancy of pain--is often more unpleasant than the unlearned avoidance of pain itself. In general, the greater the pain originally experienced, the greater the fear.

Anger-Anger seems to be almost universally aroused by frustrating situations, that is, situations in which a person cannot reach his goals. It has been suggested that the degree of anger evoked in a situation seems to be a function of the strength of the motive will be satisfied. In addition both the degree of anger and the ease with which it is elicited are dependent to some extent on the hormone level of the body. Increasing the level of testosterone (a male sex hormone) increases the tendency to react aggressively.

One of the major tasks of socialization is training in the management of anger and aggressions. We learn to express anger in words rather than actions. Everyone meets frustrations, and the expression of anger and aggression is severely limited by the culture.

Adrenal Glands-Recent research suggests that the type of reaction to stress, fear, or anger may be related to the adrenal secretions. The adrenal medulla, which secretes epinephine, also secretes another similar hormone called norepinephrin.

Physiological Basis of Feelings-When we look at someone and say he is excited, we infer his aroused state from many characteristics: a flushed face, sweaty palms, rapid breathing, tensed muscles. These signs are behavioral manifestations of an active sympathetic nervous system. Sympathetic nervous system activity speeds up the heartbeat.

It causes the liver to release sugar into the blood stream, and this permits greater energy to be used. It causes the blood to clot more quickly so that wounds will be less damaging. It stimulates the thyroid gland so that metabolism is increased; breathing rate and muscular tenseness increase.

An additional result of sympathetic nervous system activity is an increase in the secretion of epinephrine from the adrenal glands. Epinephrine circulating through the blood has the same effect as the sympathetic nervous, thus augmenting the nervous system messages.

In the aroused organism, there are also changes in brain activity. The activity of the reticular formation of the brain increases, thus bombarding the cortex with nonspecific activity. An injection of epinephrine into the blood supply near the reticular formation will have the same effect.

All these physiological changes produce an organism which is aroused for sudden and violent action, both physically and mentally.

References-

Gordon, Ira J. Human Development. (New York: Harper and Row, 1962.)

McKeachie, W. J., and Charlotte Doyle. Psychology. (Mass.: Addison-Wesley Publishing Company, Inc., 1966.)

Euphoria-Maslov tells us that our basic physiological drives, must be reasonably satisfied before we are capable of functioning effectively with our higher level of intellectual capacity. A general feeling of euphoria may pervade us at the stage of self-realization which is subsequent to the satisfaction of certain psychological needs.

PSYCHOLOGICAL NEEDS

Love

One of our major emotional reactions is love. Love may be defined as a strong attraction toward another individual.

Children love their parents because of earlier experiences. When children are very young, the parents provide for their basic needs. If hungry, the child is fed. If thirsty, he is given liquids. He is cuddled when tired, warmed when he is cold and given toys to amuse himself.

As children grow older other needs are satisfied by parents. It does not seem strange, therefore, that considerate parents will become the object of great attraction to their children.

Questions:

1. If you have a dog, think of the things that you have provided for him to create an attraction to you.
2. What have your parents done for you to help create an attraction toward them?
3. What happens if a person or animal disturbs a baby bear and the mother is close by? Why does she react in this manner?

Need for Achievement:

Each individual carries within himself, from birth to death, certain inner springs of feeling that may be aroused by any of a number of stimuli, and certain desires that are of such fundamental importance to him that he constantly seeks gratification for them. One of these needs which everyone shares is the need for achievement and recognition of that achievement. This does not manifest itself in the same way in every person, since the miser or the millionaire

3neg

may feel the need to acquire and hold a large sum of money to feel a sense of achievement, while a demagogue's deepest desire is to control others.

The natural ego of a person demands the satisfaction of achievement in order to let that person react in a completely natural manner. If this satisfaction is withheld, the tensions, without finding an outlet, become greater. Eventually the urge will find some means of expression that gives some form of relief. If time goes by with this situation unchanged, the individual will seek recognition and achievement from some other group. Often this is a deliquent group which, like him, has been unsuccessful in obtaining recognition and social acceptance by its peers.

We also have physical responses to emotions. Intense fear or anger provokes a vast complex of internal changes. These changes enable an individual to exert maximum strength on an emergency basis. Undoubtedly the involuntary activities of the body in strong emotion helped primitive man to survive. Also the extra surge of activity, making use of the extra sugar in the blood and the other acute emergency responses, acted as a release valve to allow the individual to return to a normal state. In many emergencies modern man, by contrast, is called upon to repress his emotions. Because he cannot meet the emergency by direct physical action he denies his body its natural release mechanisms. Unless man can find some satisfactory way to express his emergency emotions, they may handicap rather than help him in making an effective response. In addition, the visceral activity involved in emotion can result in physical illness if it continues over a long period of time. Over a period of years through conditioned learning each of us has come to associate certain feelings with certain words without being aware such learning was taking place.

Experiences:

Reacting to different words. Why do you react the way you do to certain words, such as:

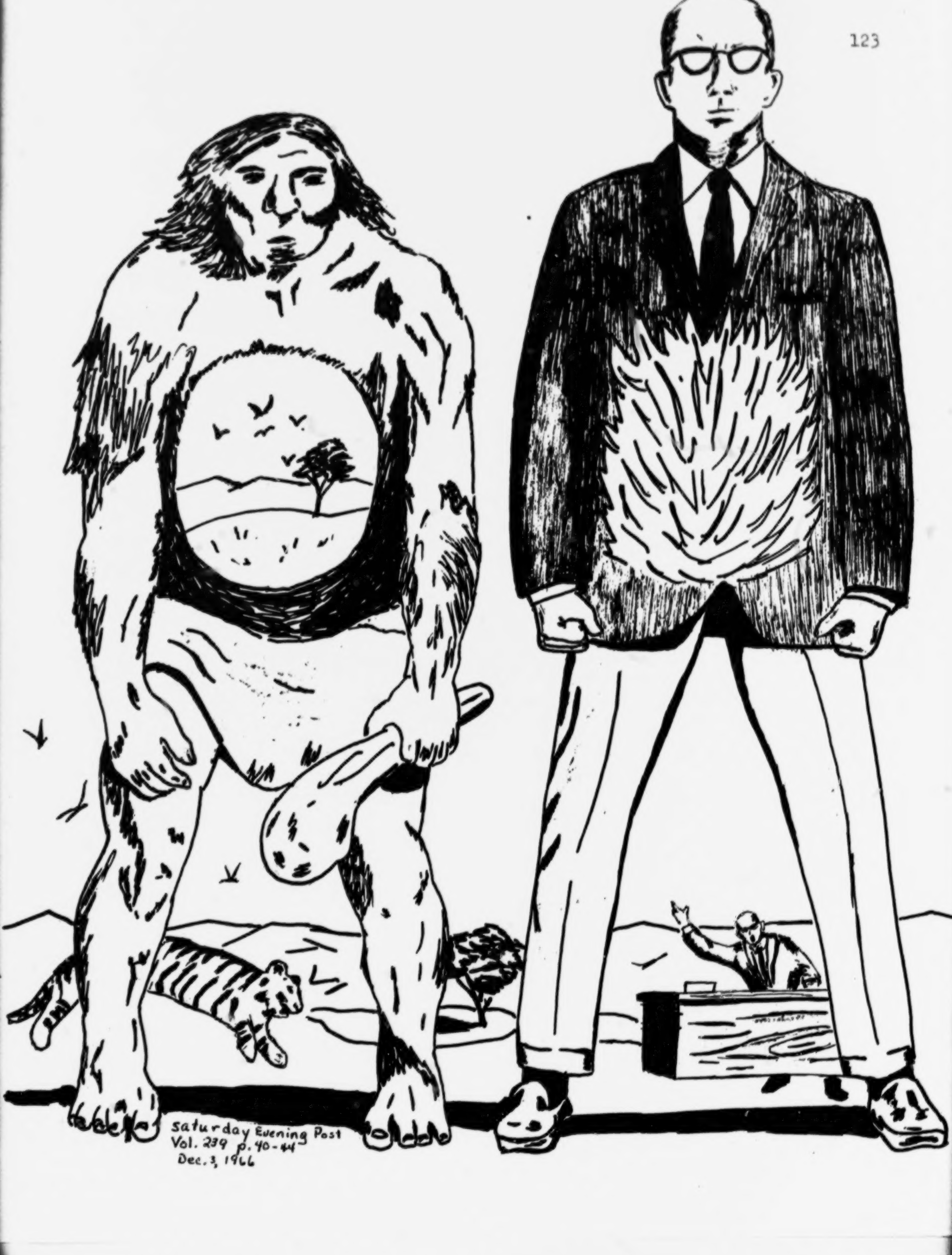
A. mother
B. Bible
C. Beatles
D. pus

E. water
F. blood
G. teacher
H. watermelon

In our previous discussion we discussed how certain physical changes associated with emotions have helped man to survive by making his reactions faster and stronger. These same physiological changes which ordinarily occur at a level of unconscious or unawareness can work to detriment in modern society. These physiological changes demand action that will use up their energy and let man once again return to a relaxed or peaceful state. Primitive man could strike out at the source of his fear and threat to his security. But modern man cannot strike out at his boss, his clients, his antagonizer, his wife, and still have the social approval that he so intensively desires. Often he cannot even consciously identify the course of his emotional fear. (See picture on following page) Somewhat removed but dramatic examples of unconscious fears are the phobias that plague some men. These phobias, like many other feelings have been learned, but the learning experience has been pushed into the unconsciousness.

A. Claustrophobia (close places)
B. Hydrophobia (water)

C. Acrophobia (heights)
D. Pyrophobia (fire)



Saturday Evening Post
Vol. 239 p. 40-44
Dec. 3, 1966

Some questions related to learning, to emotions, and to the unconsciousness are:

1. Why do you react to other people's opinions the way you do? (Collect some controversial topics to show this)
2. Why do you react the way you do to people's names? (Do they call to mind someone you don't like?--do like?) Collect some famous contemporary names to show this.
3. Why are you offended by some people at first sight? (Do they look like somebody you used to know that was a cheater, bum, borrower.)

What causes first impressions?

Many times you meet people whom you like (or dislike) right away. Your conclusion may be emotionally based on how this new acquaintance treated you. Past learning experiences may have influenced your conclusion if the new acquaintance exhibits some characteristics you deem as contributory to the conclusions you have drawn in respect to older acquaintances. Or, you may not be aware of why you like or dislike a new acquaintance because you have unconsciously learned to associate certain feelings with key attributes of the new acquaintance.

How important are first impressions?

Researchers have given us adequate evidence that first impressions tend to endure to some extent regardless of how the new acquaintance performs and we tend to continue to judge the new acquaintance's behavior on the basis of our first impression. Since the behavior continues to be judged in the same way, the response to the new acquaintance is also influenced in the same direction. It seems the first impression serves as newly formed colored glass and later interpretations of behavior continue to be seen in the same first dim light.

For experiments demonstrating the "Primacy Effect" - consult the following references:

Luchins, A. S. The Order of Presentation in Persuasion. Primacy-Recency in Impression Formation. In C. I. Hovland (Ed.), Vol. I, (New Haven, Conn.: Yale University Press, 1957.)

Strecker, Edward, Kenneth Apel. Discovering Ourselves. (New York: The Macmillan Company, 1962.)

Gordon, Ira J. Human Development. (New York: Harper and Row, 1962.)

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Ruch, Floyd L. Psychology and Life. (Chicago: Scott Foresman and Company, 1963.)

Objectives

1. To work toward getting a better and broader understanding of the scientific factors involved in my own rate of growth development.
2. To get acquainted with the science factors involved when the various growth patterns of each individual are recognized.
3. To understand the varying characteristics and needs of adolescents that can be provided for as they develop.
4. To discover and understand the meaning of vicarious learning as it affects adolescent behavior.
5. To pursue the personal meaning of ideas, values, experiences and the effect of cultures.

Experiments or Experiences

A developmental program may be used in studying and considering the behavior of children, with its attention to the physical, intellectual, social, and emotional growth of children.

Example of Developmental Tasks:

The list of major developmental tasks proposed by Havighurst can be used as a guide to curriculum development based on the development of the maturing individual.

Developmental Tasks of Adolescence:

1. Achieving new and more mature relations with age-mates of both sexes.
2. Achieving a masculine or feminine social role.
3. Accepting one's physique and using the body effectively.
4. Achieving emotional independence of parents and others.
5. Achieving assurance of economic independence.
6. Selecting and preparing for an occupation.
7. Preparing for marriage and family life.
8. Developing intellectual skills and concepts necessary for civic competence.
9. Desiring and achieving socially responsible behavior.
10. Acquiring a set of values and an ethical system as a guide to behavior.

Janet A. Kelly describes developmental tasks. She is also concerned with junior high students, and using the characteristic aspects of adolescence, she concludes that the developmental tasks are "variously listed as the adolescent: (1) coming to terms with his own body, (2) learning new relationships with his age-mates, (3) achieving independence from the home, (4) achieving social and economic status, and (5) acquiring self-confidence and a philosophy of life."

Establish Self-Discipline, Control and Understanding of Growth Patterns:

1. By psychological insight into causes of behavior problems.
2. By knowledge and understanding of the development and growth patterns of adolescents.
3. By knowledge and use of group processes in daily living.
4. By knowledge and use of the thinking processes in daily living.

5. By learning and living in accordance with good mental and emotional health practices.

6. By working and planning for greater self-motivation, creativity, and resourcefulness in classroom activities.

7. By organizing the group for all-around learning climate in the classroom and the school.

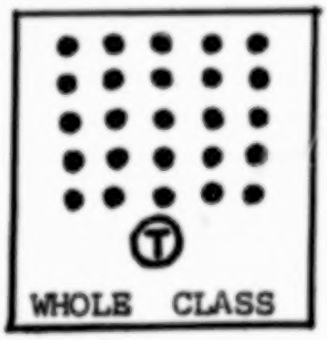
References

Havighurst, Robert J. *Human Development and Education*. (New York: Longmans, Green and Co., 1953.)

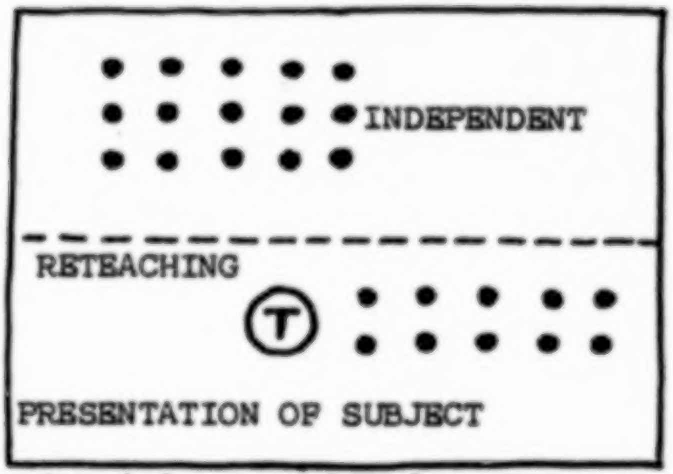
Kelley, Janet A. *Guidance and Curriculum*. (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1955), pp. 32-33.

Combs and Snygg. *Individual Behavior, A Perceptual Approach To Behavior*. (Harper & Row, Publishers, 1959.)

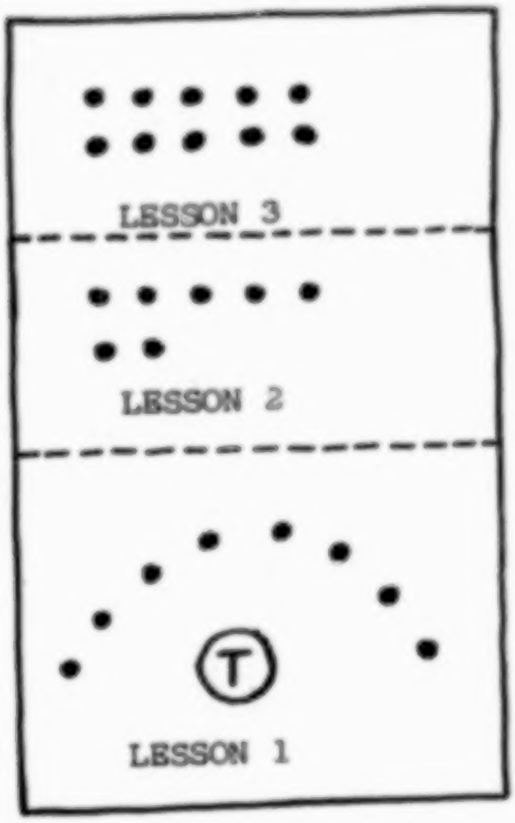
Grouping provides opportunities for children to meet developmental needs. Those with a particular interest, ability, or talent for a field enter the program best suited to them.

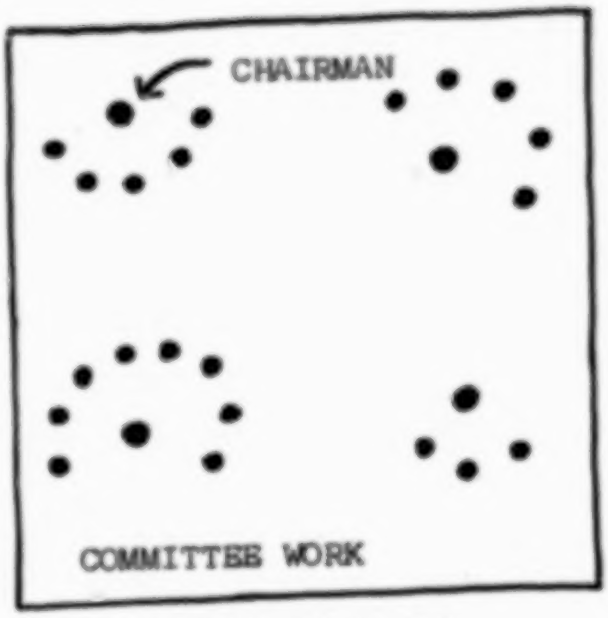


General Guidance



Special attention for those needing assistance





Self Directed

There are times when groups function as independent units without direct teacher involvement. Such groups, often referred to as committees, can provide excellent opportunities for individual learning.

OBJECTIVES AND QUESTIONS ON PHYSIOLOGICAL DRIVES

A. Physiological Drives

1. Hunger - Objectives

    a. To show that the sensation of hunger and stomach contractions are related.

    b. To show that stomach contractions can be controlled by blood transfusions. (Blood sugar composition)

    c. To show that certain portions of the brain (hypothalamus) can bring about stomach contractions when stimulated with electricity.

Hunger

The physiological drives expressing inate wants and needs related to survival are in a large part satisfied (with the exception of sex) in an adolescent's home. Some of these drives involve hunger, thirst, the need to breathe, elimination, sex, rest, and avoidance of pain.

A search to discover the physiological correlates of the hunger drive were made by the famous physiologist, Cannon, in 1934. He quite naturally supposed the stomach must be involved. With the knowledge that the stomach is a somewhat thick-walled muscular sac, Cannon decided to investigate if the stomach's muscular contractions were related to the sensation of hunger. By having human subjects swallow a balloon, inflating the balloon, and attaching the balloon to a recording device it was shown that, as the stomach muscles contracted, pressure was exerted on the balloon with resulting changes in air pressure. At the same time, each subject pressed a telegraph key whenever he felt hungry. The result was a high positive correlation between sensation of hunger and stomach contractions.

What initiates stomach contractions? Two dramatic studies yielded a clue about the answers (Luckhardt and Carlston, 1915; Templeton and Quigley, 1930). Blood from a hungry dog transfused into a dog with a satiated appetite produced stomach contractions in the satiated dog. Reversing the situation by transfusing blood from a satiated dog to a starving dog stopped the stomach contractions in the starving dog.

Since initiation and cessation of stomach contractions can be controlled by blood transfusions, it can be concluded that a link exists between the chemical condition of the blood and stomach contractions. What is the nature of the link? It has been hypothesized that the amount of blood sugar in the blood serves as a hunger stimulant and suppressor. Perhaps some hormonal condition is responsible. We can see that the problem, although involved with psychology, has physiological aspects which are revealed to be more and more complex as we search ever deeper. Each new answer uncovers a new question.

Hunger cannot be described in terms of a simple cause and effect sequence. We know, for example, that stomach contractions are not essential to the hunger drive because humans who have had their stomachs removed as a consequence of injury or disease, still report sensations of hunger. Rats who have had their stomachs removed react in similar ways to rats with stomachs, in learning problems that involve food as a reward.

This evidence leads us to conclude that certain steps in the physiological chain of events involved in hunger can at times be bypassed.

Of course, the brain must also be considered when a systematic attempt is made to understand the physiological correlates of the drive. Electrical stimulation of certain portions of the hypothalmus, a major structural unit of the brain stem, is known to produce stomach contractions. By contrast, electrical stimulation of other parts of the hypothalmus can stop stomach contractions. It could be concluded that the functioning of the hypothalmus is closely tied to the drive to eat. Supporting evidence for this conclusion comes from studies involving surgical lesions in a rat's hypothalmus. When certain parts of a rat's hypothalmus are destroyed, the rat's eating rate is increased enormously. In fact, an individual rat may double its weight in a period of two months (Miller, 1957). On the other hand, the removal of small portions of a different area of the hypothalmus can eliminate eating behavior entirely. The hypothalmus apparently contains neural centers capable of turning on and turning off the hunger drive. It would seem that an interrelated chain of events are involved in the sensation of hunger and its cessation. Blood chemistry, including blood sugar percentage level, could affect an area of the hypothalmus, creating hunger, stomach contractions, secretions and other hunger connected activities. When a change occurs in the blood chemistry representing satiation of food needs another area of the hypothalmus is affected, resulting in the termination of hunger activities. This rationale does not encompass the effect of multiple drives or unusual circumstances.

Hunger can be more specific than just a craving for food. In our own experience we can remember a hunger drive for something special such as a craving for some homemade bread piping hot from the oven. Although commercial bakery bread is cheap and would stop our stomach contractions there are times when we have expended much extra effort and money to fulfill a special desire for something like hot bread. After weeks of maceroni we might develop a specific hunger for a thick steak. Such food-seeking behavior is directed toward particular kinds of reinforcements. One such reinforcement is illustrated by rats exhibiting a definite preference for sugar after having been kept on a sugar-free diet and given a choice of sugar, wheat or fat. Similarly, by presenting a choice of sugar, wheat, or fat to rats on a fat free-diet it was found that they exhibited a preference for fat. As a check,rats deprived of wheat were found to prefer wheat. Rats have also been shown to exhibit a preference for salt, sodium, calcium, phosphorus, thiamine, and riboflavin after having been on a diet deprived of these essential food substances.

The rats apparently responded to specific hunger drives that correspond remarkably to their optimum needs.

Cafeteria experiments, where the organism is free to choose from a large number of foods, have shown that cows, pigs, and chickens have been able to select a balanced diet (Young, 1933). Davis (1928), carrying out experiments in a hospital for over a year was able to show that human babies were able to select a balanced diet that enabled them to develop just as well as other babies whose food requirements were balanced for them. Some of the babies ate heavily of certain foods like banana or liver for a time. A child suffering from rickets when the experiment started voluntarily selected cod-liver oil.

It is evident that some organisms have specific hunger drives each of which requires a specific food. Somehow, many organisms are able to choose the foods that satisfy each specific hunger. If some organisms can balance their food intake as a result of natural hunger drives why don't all organisms do so? A look at a few adult humans can give us convincing evidence that food intake imbalances happen frequently.

We know three different causes for inadequate diets. First, not every specific diet need produces a specific hunger drive. As has been stated, fat-starved rats prefer foods containing fats. However, rats deprived of vitamin A do not show a preference for food rich in vitamin A (Wilder, 1937). Sometimes protein-deprived rats are seemingly incapable of choosing the foods that would correct the deficiency. The second cause of inadequate diets are social customs or social training. The people of Asia who by social custom eat little other than polished rice, frequently develop a vitamin B_1 deficiency which, in severe cases, causes the disease beriberi. People can create imbalance in their diet by developing strong preferences for, or aversions to particular foods. An intense socially acquired desire for candy or a strong dislike for cereals or vegetables could lead to an undernourished condition. We can even train rats to select foods that do not meet their basic needs. The third reason an unbalanced diet may be chosen is that an organism may develop an appetite for foods unnecessary to them. Rats have repeated learned acts for a reward of saccharin, which tastes sweet but has no nutritional value (Sheffield and Roby, 1950). Humans, the world over, often imbibe alcoholic beverages in preference to more nourishing drinks or even in preference to food.

The act of eating is quite complex. We have not one but many hunger drives. Our bodies have mechanisms enabling us to choose foods to satisfy some but not all of our specific hungers and by learning we can modify our normal cravings and develop hunger drives and choices that go counter to our own dietary needs.

Environmental conditions can strongly influence what is eaten. Chickens will devour more from a large pile of feed than from a small one even when the small pile is too large to be completely eaten (Bayer, 1929). Seeing someone with a delicious looking meal may enlarge the scope of your previously small desire for food. This just shows that an outside stimulus can influence the strength of a hunger drive.

It can be seen that the hunger drive can correspond to hunger need but that the drive is in certain areas insufficient. It can also be concluded that the hunger drive can be trained in ways that make it at least partially misrepresent true body needs.

Questions on Hunger-

What initiates stomach contractions?

The chemical condition of the blood (blood sugar), and some hormonal conditions initiate stomach contractions. This was shown in the studies of Luckhardt and Carlson, 1915 and Templeton and Quigley, 1930.

Does the brain control stomach contractions?

Yes! Research has shown that the brain must also be considered in studying what governs stomach contractions. Contractions have been evoked by direct electrical stimulation of certain portions of the hypothalamus, one of the parts of the hypothalamus can stop hunger contractions. (Stellar, 1954).

Is hunger a unitary drive?

It would be difficult to create the impression that hunger is a unitary drive because it is more appropriate to think of hunger as specific rather than unitary.

Example: Bread would stop stomach contractions, but T-Bone steak might prove more hunger appeasing.

Can external stimuli influence the intensity of a hunger drive?

Yes! Example: You may enter a restaurant intending to get a "bite to eat" but happen to see someone else devouring steak and French fries and suddenly you find yourself ordering the same. Therefore, an external stimulus can influence the intensity of the hunger drive.

2. Thirst - Objectives --

   a. To show that our bodies demand a minimum water level, below which death results.

   b. To show that the degree of dryness of the tissues in the oral cavity does not of itself determine the strength of the thirst drive.

   c. To show that the dryness of the throat and mouth do not determine how much water one will drink.

   d. To show that certain physiological factors are responsible for the maintenance of the proper water level in the body.

   e. To show that dryness of the mouth and throat tissue plays much the same role in the thirst drive as stomach contractions do in the hunger drive.

Questions on Thirst-

Does dryness of the mouth and throat tissues alone determine the sensation of thirst?

No, they only serve as a primary cue because as the water supply in the mouth lessens, and the throat and mouth become dry, tiny nerve endings imbedded in the tissue are stimulated. The organism then has a sensation of thirst and in turn a drive for the relief of thirst is initiated. Wetting the dry tissues by drinking water or some other beverage reduces the sensation of thirst.

Does the dryness of the tissues in the oral cavity determine the strength of the thirst drive?

No. Montgomery, in 1931, compared an experimental group of dogs whose salivary glands had been removed with a control group whose salivary glands were left intact. The experimental group drank more water than the control group.

What physiological factors are responsible for the maintenance of proper water level in the body tissues?

It appears that these factors are found in the blood and brain. Located within the hypothalamus are cells that are extremely sensitive to water loss. Direct dehydration of the cells of the hypothalamus by an injection of a salt solution results in excessive drinking. It is thought that the water level of these sensitive cells in the hypothalamus is controlled by the chemical and hormonal condition of the blood. When the blood stream, similar to the hypothalamus, has been subjected to excessive amounts of salt the animal will react by drinking.

In what respects are the hunger and thirst drives alike?

They are alike in that the blood and hypothalamus govern both drives.

What other liquids could safely be substituted for water?

Wine, milk, carbonated beverages, coconut milk and many other palatable water solutions not containing harmful substances could be substituted for water intake. The need for water is rated differently by most Americans than by people who have a scarcity of supply. Water could be the prime need at certain times in a person's life.

3. Pain - Objectives--

   a. To show that pain is an avoidance or aversive drive rather than an appetitive drive such as hunger, thirst and sex.

   b. To show that pain is a sensation as well as a drive.

   c. To show that pain varies.

   d. To make students aware that pain can be influenced by learning and perceptual processes.

   e. To show that painful-drive states are psychologically important, since they provide a basis for learning other forms of motivations.

Pain is the last drive to be treated here in detail. This drive differs greatly from the drives discussed earlier. The pain drive is an avoidance drive or an aversive drive. In order to eliminate pain, an organism moves away from the source of noxious stimulation. The organism does not always make consummatory responses to an incentive, as it does for approach drives. Usually he merely tries to escape from the painful stimulation. One will understand this distinction from the study of positive and negative reinforcers. A positive reinforcer, such as food, water, or a mate, strengthens the association between the stimulus and response by its presentation. Approach or appetitive drives have positive reinforcers. Negative reinforcers, such as an electric shock, strengthen an association by their removal; avoidance or aversive drives have negative reinforcers.

Pain is said to be a sensation as well as a drive. It has been discovered that some children constantly injure themselves because they are born without the normal sensitivity to pain. Receptors for pain are free nerve endings widely distributed throughout the skin, muscles, blood vessels, and internal organs. These nerve endings can be stimulated by a variety of encounters within the environment. Pain receptors are usually stimulated by tissue damage, but not always.

Pain receptors vary in their placement in the anatomy, where difficult forms of stimulation are required to initiate activity in different receptors. To support this idea it has been stated that burns or cuts will stimulate pain receptors in the skin, but certain internal organs such as the intestines may be cut or burned without evoking any painful sensation.

Numerous facts support the idea that what we feel as pains can be influenced by learning and the perceptual processes. In our culture some authors state that some experiences are painful just because they have been experienced by one individual, whereas other authors say the pains felt are due to fear.

It has also been proven that in addition to providing sensation, pain functions as a drive, for organisms are motivated to eliminate or relieve pains felt by them. The organism can learn a wide variety of responses that will help eliminate or relieve pains felt by them. The organism can learn a wide variety of responses that will help eliminate many painful drives.

Some body needs are met by reactions made to avoid pain.

Questions on Pain

How is the pain drive different from the drives of sex, hunger, and thirst?

It differs in that pain is an avoidance. An organism will move away from the source of painful stimulation whereas in hunger, thirst and sex the organism must approach a goal and make appropriate consummatory responses.

Why would pain be considered a sensation as well as a drive?

Receptors for pain are free nerve endings widely distributed throughout the skin, muscles, blood vessels, and internal organs. There free nerve endings can be stimulated by a wide variety of encounters with the environment such as excessive pressures, burns, cuts, or electrical shocks. Pain receptors are usually stimulated by tissue damage, but not always. Tissue damage may also occur in the absence of any immediate pain sensation. (e.g. sun-burn)

How would variable pain be described?

Pain produced by a hypodermic needle puncturing the skin is different from a muscle ache, which in turn is different from a headache or stomach ache. Reference in terms of changes in pain may be referred to as fast pain (carried by relatively large myelinated "sheathed" fibers) and slow pain which is transmitted by small fibers with little or no covering. Pain is not always due to receptors but sometimes can be traced directly to the brain which brings about the necessity for severing the connections between the receptors and the brain in order to stop intense and continuing pain (intractable pain).

How may pain be influenced by learning and perceptual processes?

Example: During World War II it was observed that only about one out of every three severely wounded soldiers complained of enough pain to require morphine while being moved from the combat zone to the hospital. In contrast, four out of five civilian patients with similar wounds need morphine to relieve their intense pain.

American women often fear childbirth because they associate the process with learned fear. On the other hand, in other cultures where child birth is taken casually, less pain is associated with the process.

How does pain function as a drive?

Pain functions as a drive because organisms are motivated to eliminate or relieve the pain they feel.

Example:

a. A cough, which is a reflex can sometimes eliminate discomfort to the throat.

b. A pain produced by foreign material in the eye can sometimes be reflexively eliminated by eye-blinking with tears.

4. Sleep - Objectives--

a. To show students that the pattern of behavior by which we satisfy the need for sleep is largely the result of cultural factors.

b. To show that most individuals require 6 to 9 hours of sleep daily.

c. To show that the nerve and brain centers are perhaps directly stimulated by chemical conditions within the body.

The need for sleep is largely due to results of cultural factors. It has, however, been suggested that sleep might be partly chemical because of certain drugs which can be used to induce relaxation resembling sleep.

It is known that injury to the lower brain centers can cause sleepiness, therefore, perhaps these centers control this psychological drive.

Studies have shown, by Clark, Joffman, Hudson, Mead, Searle, and Wagoner in 1946, that it is possible to do without sleep for one hundred hours with a slight loss in efficiency in doing short tasks. However, complex tasks which require more efficiency cannot be accurately done with a sleep loss of fifty hours.

The need for sleep varies in people and most require 6 to 9 hours daily in order to perform given activities during the course of a fifteen hour day.

Questions on Sleep

How would cultural factors influence the behavior of sleep?

Most cultures base their sleeping patterns on the alternation of light and darkness which varies by location and season.

What differences are there between fatigue and sleep?

Fatigue seems to result from frustration, worry, or boredom, whereas sleep may be partially chemically induced. In becoming sleepy, our nerve and brain centers are perhaps directly stimulated by chemical conditions within the body.

Does loss of sleep bring about loss in efficiency?

Studies show that it is possible to go without sleep for as long as 100 hours with only slight losses in efficiency in performing short tasks. In complex tasks performance declines significantly during the course of 50 hours without sleep.

5. Temperature (warmth and cold) - Objective--

To show students the physiological origin of warmth and cold.

Temperature in the human body is regulated by a complex mechanism that balances heat loss and heat production. This involved two temperatures: Heat in the environment and heat produced by the body. The hypothalamus responds to the temperature of blood flowing through it and seemingly is most vital in the body's adjustment to heat and cold.

When the body experiences cold, body activity is stimulated. The hormones, thyroxin and adrenaline, help increase body activity. These hormones stimulate muscular activity which brings a rise in blood pressure. Blood is then driven from the skin to deeper tissues where it is no longer subjected to cold.

Heat reactions differ considerably. When outside temperature rises the body activity slows down. Blood vessels which occur at the surface of the body dilate which allows more blood to be exposed to cooling. This in turn causes perspiration. Sweat, a liquid, helps cool the body surfaces by acquiring heat from our body to attain its "heat of vaporization" and changing to water vapor a gas. Of course, when the relative humidity is 100% the body's cooling system can no longer operate.

All of these changes, which are automatic, act in various ways to keep the temperature of the body tissues at a fairly constant 98-99 degrees Fahrenheit regardless of environmental temperature.

Regardless of the automatic changes in the body to warmth and cold many things are done to keep our bodies at a comfortable temperature. These include: air conditioners, hot drinks, suitable clothing, electric fans and many others. These are only a few of the results of man's drive to adjust to warmth and cold.

Drives for warmth and coolness are linked to a need of the body to maintain a constant temperature.

Questions on Warmth and Cold

What determines sensitivity to warmth and cold?

Receptors in the skin regulate sensitivity to warmth and cold.

What regulates temperature in the body?

The interaction between the amount of heat in the surrounding environment and the heat produced by the body itself stimulates the regulation of body temperature. The hypothalamus plays a vital part in the adjustment of the body to heat and cold by triggering the release of hormones which indirectly bring about an increase in body warmth or coolness.

6. Sex - Objectives

   a. To show that sex is second only to hunger in its implications for social living in our society.

   b. To show its influence on human behavior.

   c. To show that sex is not essential to remain alive.

   d. To show that sexual urge is dependent, in part, on blood composition.

   e. To show that the strength of sexual drive is greatly influenced by the presence or absence of hormones; the most important determinant of sexual behavior found in the testes of males and ovaries of females.

   f. To understand that satisfactory sexual adjustment is important to mental health and effective living.

The sexual drive is second only to the hunger drive in its implications for social living. Our social structure limits an individual's sexual behavior. Awareness of sex urges are more persistent and more insistent than that of other drives which are not likely to go unsatisfied. Although sexual activity is necessary for the survival of the race, it is not essential for keeping an individual alive. However, the writer feels that satisfactory sexual adjustment is important for mental health and effective living.

The sexual drive in the male is felt to be important, because it is steered by the androgens, which are hormones secreted by the testes and certain hormones secreted from the pituitary glands.

Male sexual urges are to be said to reach their peak in the late teens and start to decline in the early twenties. The gradual falling off of the sexual urge is caused largely by a decrease in the androgen secretion.

Many authors feel that the sexual drive of the female is more complex than that of the male. The primary sex organs of the female are the ovaries. The ovaries are responsible for the secretion of the female sex hormones which are the estrogens, which in turn influence the sexual urge, and the progesterone, which is important in pregnancy.

The estrogen secretion which flows into the bloodstream is greatest each month just before and after ovulation, when a mature egg cell is released down the oviduct, a tube leading from the ovary to the uterus. Most medical experts believe that, in the adult human female, ovulation occurs about halfway between two menstrual periods.

They also believe that the brief time while the egg is in the oviduct is the only time fertilization may occur.

Despite the anatomical differences, the physiological responses of men and women during sexual activity are very similar. Both men and women can respond as rapidly as the other. The copulatory sex organs of men and women are really similar and respiratory and blood pressure changes in men and women during copulation are also similar. Many writers feel that women often have to be stimulated more than men for sexual satisfaction because of the negative attitude so often ingrained during early life. This sometimes causes females to become psychologically frigid, even though they are in perfect health biologically. Many men, on the other hand, pursue the opposite sex for sexual intercourse as if such occasions were personal conquests on their part. This deprives the act of dignity, true sharing of affection, and consideration of others (including possible offspring).

As an expression of need sexual drive represents an urgency for self-fulfillment as well as a need to perpetuate the species. Although the rules of society create serious problems for adults with sexual needs, scientists would be rash to advise complete abandonment of our moral structure. The problems that exist however, suggest that society should recognize that they need careful, diligent attention toward finding answers.

Questions on Sex

Why is sex rated second only to hunger by some psychologists in America?

Our society does not govern food-taking behavior whereas sexual expression is closely governed by law and social conventions.

What regulates sex behavior in the male?

Sex is regulated by androgens (hormones) secreted by the testes and hormones secreted by the pituitary. The sexual urge reaches its peak in the late teens and starts to decline in the early twenties. (Kinsey, Pomeroy, and Martin, 1948)*

What regulates sex behavior in the female?

In the female the ovaries are responsible for the secretion of the principle female sex hormones, the estrogens, which influence the sexual urge and progesterone which is important in pregnancy.

How is sex important in everyday life?

Certainly sex is not necessary in keeping individuals alive. However, sex is necessary for the survival of race and it is most important for effective living and mental health. Common causes of sexual maladjustment can be said to be inadequate sex education, perversion or debasement of expectations and indulgence and unreasonable restraint of expression and fulfillment.

Evaluation:

One of the hardest things to do is to look at ourselves, our thinking and our actions, with any semblance of true objectivity. Humans have a marvelous capacity to rationalize their own actions, no matter how foolish or ill-chosen. Then too, people tend to remember more those past experiences, or facets of experiences, which are favorable to them. In the field of literature this principle is known as "recollection in tranquility." These procedures undoubtedly

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*Taken from--
Ruch, Floyd L. Psychology and Life. (Chicago: Scott, Foresman and Company, 1963).

contribute toward a more tranquil self, but, let's see if our knowledge of psychology can help us be more effective ourselves and be more understanding of others. Using the three check lists found in the section on self-concepts try: first, to evaluate yourself; second, jot down rationalizations you tend to make in your behalf; third, list some of the shortcomings you tend to leave on the edge of your memory; and fourth, give a positive new step you could take toward self-improvement if you felt motivated enough to change. Do you see any value in exploring for further knowledge in the field of psychology?

CHAPTER VI

IS THE POPULATION OF THE WORLD IN GENERAL CONCERNED ABOUT NATURAL RESOURCES?

Objectives

1. What should I know about the availability of natural resources in the world?
2. Will there always be plenty of natural resources to serve the needs of the growing economy of the world?
3. What things are being done by manufacturers and suppliers today in order to provide me with a higher standard of living than any previous generation has experienced?
4. What are some of the things that professional biologists have done to increase our food supply?
5. What personal responsibility do I have to help man survive in our crowded future world?

How many individuals living today concern themselves with problems of the future or ultimate adequacy of world resources? One might say that the majority of the world's population are so involved in the struggle to survive in today's world that they do not have energy or time to spend toward solving food problems of the world in the future. Public concern, however, is reflected in the deliberation of many academic, industrial and political groups throughout the world. Research has contributed much in the right direction but ever more extensive efforts will be needed as the problem becomes more acute. A significant shortage in the worlds' food supply by 1975 was predicted by Orville Freeman in 1966.

When leaders examine the increasing population, and a per capita decrease in available food, they see mankind moving toward a catastrophe which may lead to the end of civilization as it exists today. Can we learn from the mistakes of the past?

Some people today, like Malthus in the Eighteenth Century, foresee only doom and misery for mankind in the future. Since we do not now possess the knowledge to provide for future needs of food and energy, the prospect seems dismal. However, just as Malthus could not foresee the potential expansion of steam, electrical, petroleum, and nuclear power operating in conjunction with birth control in western lands, it is possible that new energy systems and even wider-spread birth control measures will solve problems that are on the horizon. Other people are so filled with a childish faith that things are bound to turn out fine that they fail to face the problem. Perhaps they have come to expect almost automatic answers to come from the efforts of others. Generally speaking, however, the people who survived famines of the past were those who had planned and acted to provide for the future.

How extensive are our natural resources?

About thirty years ago it was thought that our petroleum reserves could not last more than fifty years. Today through energetic development of both new and old oil deposits we probably still have fifty years of oil reserves.

Prior to World War II it appeared that we had nearly exhausted the new lands which could be opened for food production. Had production rates remained unchanged, consumption of farm products would now exceed domestic supply. In actuality it became necessary to curtail the acreage devoted to agriculture, since tremendous surpluses of many foods were on hand by 1960. One should hasten to add, however, that much of the stored surplus has been eliminated since then, and we are even short of some food items for which there is a market worldwide. In 1965 our rice surplus was marketed without trouble. If one were to view the United States without considering its responsibility to the world, he would see an attractive future of abundance and prosperity for many years. Unfortunately the entire population of the world is increasingly affected by what occurs in any land. When one views the total world situation on resources he recognizes the true magnitude of the problem and realizes that we must begin operating rapidly on a large scale now, if we are to do anything about the abject poverty and the desperate plight of the world's present population. The following table prepared by Dewey Davis from Annuaire Statistique, 1964, is provided in order that you may compare a nation of great abundance of resources with one of average resources and with one of deficient resources. Since nearly 75% of the world population falls under the third category, it most accurately reflects the general condition of the world population. Just a cursory examination of the table without consideration for population depicts the United States in an enviable position. If you will compute the per capita values it will become evident that the existing natural resources in the world are not sufficient to give all peoples our standard of living.

STATISTICS FOR 1963

Country	Population	Energy Available (Kilowatt Hours)	Iron Ore (Metric Tons)
World	3,160,000,000	4,697,000,000,000	250,000,000
United States	189,375,000	1,611,110,000,000	41,542,000
Italy	50,498,000	79,220,000,000	509,000
India	460,490,000	78,360,000,000	12,404,000

Country	Newsprint & Other Paper (Metric Tons)	Passenger Cars (Units)	Lumber (Cubic Meters)
World	53,700,000	16,160,000	348,000,000
United States	16,973,000	7,637,000	297,300,000
Italy	1,620,000	877,800	16,500,000
India	410,000	30,900	very small

Country	Meat Total (Metric Tons)	Fish (Metric Tons)	Cotton (Metric Tons)
World	67,700,000	46,400,000	10,300,000
United States	13,850,000	2,712,000	3,337,000
Italy	988,000	232,000	5,000
India	probably less than 700,000	1,046,000	977,000

STATISTICS FOR 1963
(Continued)

Country	Wool (Metric Tons)	Electrical Energy (Kilowatt Hours)	Coal (Metric Tons)
World	1,520,000	2,849,200,000,000	1,929,000,000
United States	130,000	1,011,215,000,000	430,450,000
Italy	15,000	71,353,000,000	585,000
India	35,000	26,227,000,000	65,956,000

Country	Synthetic Fabrics (Metric Tons)	Milk-All Kinds (Metric Tons)	Gasoline (Metric Tons)
World	1,331,000	358,300,000	279,500,000
United States	520,000	56,601,000	166,250,000
Italy	28,980	9,247,000	6,533,000
India	1,040	21,200	1,399,000

Country	Sugar (Metric Tons)	Wheat, Rice, Corn, and Potatoes (Metric Tons)
World	51,900,000	1,017,100,000
United States	3,416,000	149,919,000
Italy	913,000	16,805,000
India	2,502,000	59,980,000

By utilizing appropriate mathematical manipulations one discovers that each citizen of the United States has far more available to him than a citizen of either Italy or India.

Country	Kilowatt Hours per person per year	Pounds of Meat per person per year	Pounds of Grain per person per year	Pounds of Cloth per person per year
World	1,136	47.2	709	9.1
Italy	1,413	42.8*	732	2.1**
India	569	3.4	287	4.8
United States	3,480	160.5	1,740	46.5

*Italian people consume a large amount of olive oil.
**Italy is a large importer of clothing fibers.

If you lived in India, the total amount of meat that would be available to you on the average would amount to 13 hamburgers per year. Since the bone is included in calculating meat production the ration would reduce to less than one hamburger per month. If you prefer steak, your total meat allowance would be equivalent to four steaks per year.

Suppose you had to cut the amount of energy available in your home to one-sixth of what it is. What things would you have to do without? Suppose you were told there would be only 2 gallons of gasoline a month for operating the family car. How many trips would you take? Is this why more adult people in the world ride bicycles than drive automobiles?

Nearly everything we use or eat is provided for us by our natural resources. Most of our natural resources come from the earth. How much of the earth is available for agriculture?

LAND AVAILABLE FOR FOOD PRODUCTION

Continent	Total Land: Millions of Acres	Millions of Acres Suitable for Agriculture	Percentage Suitable for Agriculture	Acres Suitable for Agriculture per person
Africa	7,300	240	3.3	0.75
Asia	10,400	600	5.8	0.34
Antarctica	3,400	0	0.0	0.00
Europe	2,400	890	37.0	2.03
North America	5,500	570	10.4	2.20
Oceania	2,100	60	2.9	3.57
South America	4,600	220	4.8	1.39
World	35,700	2,580	7.0	0.82

When one realizes that only 7% of the land area of the world is suitable for agriculture, it is amazing how much food is produced. After one learns there is less than one acre of suitable land per person for food production, he begins to see what a valuable resource the land is to mankind. Should we be careful about turning productive farmlands into highways and cities?

Student Activity: How much land is taken out of production when a freeway is built between Houston and Dallas (250 miles long and at least 300 feet wide)? Would it be more or less than 9,000 acres?

The forests of the world make signigicant contributions to man's welfare. It is interesting to note there are more acres of forest available for our use than there are acres of productive farmland. Millions of people still obtain their food by hunting in these forests.

FORESTS OF THE WORLD

Continent	Millions of Acres	Percentage of Land Area	Acres of Productive Forest per person
Africa	2,100	29	7.2
Asia	3,140	33	1.6
Europe	720	30	1.1
North America	1,800	33	6.2
Oceania	200	10	10.9
South America	1,870	41	10.2
World	9,830	27	3.1

What Can We Learn From History About Whimsical Use of Nature?

The natural resources of a primitive community are as simple as its needs. In such societies, the forests, the rivers, and the oceans provide in abundance for the necessities of life; food, clothing, shelter, and tools. Man is an important part of such a system, but his economic civilization causes him to modify the environment. Man has modified his environment for at least 11,000 years, and a study of his mistakes at anytime during this period, would have revealed to him that many of his modifications were detrimental to his welfare.

Plato, in his unfinished story of Atlantis, describes the area of Greece around Athens as it was supposed to have appeared about 9,000 B.C. The mountains were covered with trees which supplied ample game, fruit and logs for the inhabitants of the area. Plato realized that the natural abundance which had been a part of Greece had been destroyed by man, for in Plato's time the forests were gone and the land could only provide sustenance for bees. The richer parts of the soil had washed away and there remained only a plundered and devasted land. Man had abused the land by overgrazing and deforestation.

Arnold Toynbee describes how the Lower Nile Valley came to be settled about 4,000 B.C. Tribes residing in the region now known as the Lybian Desert had been forced to leave a virtual paradise. The area had been so abundant in its provender that an extremely dense population inhabited the area. Quite probably because of man's abuse, that area, like several in Asia, began to dry up, and vegetation began to disappear. The inhabitants were forced to change their habitat and their way of life. Those who did not adapt perished. Those who changed their way of life in order to stay in their habitat transformed themselves from hunters into shepherds, who later became known as the nomads of the Steppes. Those who changed their habitat to the North had to adjust to a new seasonal cold. Those who chose to migrate southward without changing their way of life succumbed to the soporific influence of the monotony of the tropics. A fifth group changed both its habitat and its way of life, and this dynamic group created the great Egyptiac and Sumeric civilizations which ultimately were responsible for the enlightenment of the human race.

It has been a fact of life that the impact of man on environment increases with growing density of population. Do you think area of intensive agriculture today may be destroying the abundance that had naturally resided in these areas? You might like to read Grapes of Wrath to acquire an idea about what was occurring in the mid-continental United States in the 1930's. When and how should marginal farmland be placed into production? Should we utilize more of our forests as farmland? Why do we see today so much virtually worthless farmland in Georgia, Alabama, Arkansas, and Texas, where there has been previously a vigorous and economically profitable agricultural industry?

Where Has Man Been Careless in His Stewardship of Natural Resources?

Let us examine how man has been careless in dealing with the natural resources of his environment. As we see man's abuse of soil, forest, water, minerals, and atmosphere we must also consider what preventive measures can help us avoid the utter devastation wrought by our ancestors and ourselves. Man must view himself as an extremely important factor in changing nature. Because the destruction of one natural resource will result in changes of others, we must be conscious of long term results of what we do. How other people in the world are utilizing their natural resources is of importance to us too.

Soil: It was utterly inconceivable to our forefathers that any conservation practices such as were common in Europe would be necessary in this land of abundance. Advertisements in newspapers in the early 1880's pointed to the fact that the soils were inexhaustable. By repeated burning and other bad practices, man destroyed the virtual sponge of plant and humus soil constituents that had been produced during thousands and thousands of years. The four main causes for the deterioration of land are, loss of soil structure, loss of organic matter, loss of plant nutrients, and loss of the soil itself.

To start with, there were 600,000,000 acres of good tillable land in the United States. Today we have only about 500,000,000 acres of highly profitable cropland, and this includes 100,000,000 acres that require drainage or irrigation. Since one-third of our farmland is suffering from erosion at a slow rate and one-fourth is being damaged at a critical rate, only about 100,000,000 acres are not subject to serious deterioration by erosion. About 90,000,000 acres of land now being farmed in the United States, should be retired to permanent cover. About 500,000 acres of our cropland is being lost by erosion each year. It is obvious this cannot continue, if we are to maintain our standard of living, since each cultivated acre creates about $30 worth of new wealth each year.

Student Activity: How much new wealth is being destroyed each year? How much has careless use of the land cost citizens of the United States since World WarII?

Land conservation requires that immediate steps be taken to prevent soil erosion and to conserve the moisture that falls on the land. The land must be used in accordance with its capability and needs. There must be a coordinated program for the whole farm. Some of the important practices are fertilizing, contouring, terracing, strip cropping, mulching, crop rotation, gully control, green manuring, and pasture development.

Plan some committee reports on these practices. Perhaps a field trip can be arranged to observe them. Remember that if the farmer abuses the land, you may have to pay more for food, and in face of the increasing demand for food, poor agriculture practices may be responsible for thousands of people starving throughout the world.

Forest: When the colonists settled in Massachusetts in 1620, the forest lands of what is now the continental United States exceeded 820,000,000 acres. There were over 1,100 varieties of trees and a greater diversity of species than was to be found anywhere else on the earth in a comparable area. America's virgin forests were so magnificent that they were considered inexhaustible. Billions of board feet were destroyed by people seeking new farmland, and billions of board feet were used to construct the homes, schools, churches, and factories of an expanding nation. By 1890 it became evident that unless forests were managed, this natural resource would become exhausted. Once the forests are destroyed, the cover, sponge, and anchoring effects of the trees is lost. Hence, the soil is exposed to accelerated erosion.

There are over 630,000,000 acres of forests in the United States, of which 400,000,000 acres can be considered suitable and available for timber and pulp production. At this date the only serious shortage of trees appears to be among those over 15 inches in diameter which can be used for saw timber. If we plant at least one tree for each one that is cut, our shortage of forest is not likely to become acute. The removal of tree cover in any area may cause the lowering of the water table and eventually the lack of moisture and cover can lead to extensive erosion.

Water: If we are to provide sufficient water for our growing industry as well as enough pure water for human consumption much more attention must be directed toward increasing both the quantity and the quality of water. Our least expensive and most abundant sources are natural lakes, rivers, and streams. Man made reservoirs also provide low cost water while also raising the water table in the area. Sometimes irrigation is also made possible by the formation of reservoirs. An example of a man-made reservoir would be Canyon Lake in Central Texas. Man has built a huge earthen dam across a narrow gorge of the Guadalupe River where the water, prevented from completing its journey to the sea, backs up for miles in the natural valleys which had been excavated by the river and its feeder streams during thousands of years. This program, as the Trinity River program, has been criticized because it causes inundation of thousands of acres of farmland which might otherwise be used for food production. It will also provide a dependable water supply for irrigation in areas surrounding the lake.

Man can increase his supply of water by reuse and recirculation. When sewage is handled in an intelligible manner, it may become an economic asset for a community. Chicago realizes thousands of dollars each year from its "valuable garbage." An efficient sewage system is also a valuable example of water reclamation. A visit to a sewage plant can be a very valuable learning experience.

During the last two decades man has become vitally concerned about the quality of his water supply. Throughout the last two centuries a great many new cities have been established along the Ohio River Valley. Each of these urban areas drew its water supply out of the river upstream from the city and returned its waste products downstream from the city. This multiple pollution continued largely unabated until June 30, 1948, when the Ohio River Valley Sanitation Compact was signed in Cincinnati. The pact was ratified by Ohio, Indiana, West Virginia, New York, Illinois, Kentucky, West Virginia, and Pennsylvania. Each state pledged its cooperation to reduce the pollution of the Ohio and its tributaries. If the results of this cooperation are successful in decreasing the amount of water pollutants, cities along the valley will be able to supply their citizenry a more palatable water supply at a reduced price. Similar experiences on many watersheds have recently sponsored citizen concern about the quality of the water supply.

Synthetic detergents are menacing our underground water supplies and present an obvious and difficult pollution problem for man. Alkyl benzene sulfonate (ABS) is the ingredient in synthetic detergents which causes water to foam. It resists about 50% of the bacterial action that typically has been counted upon to change soap compounds into soluble or volatile compounds.

Dr. Joe Hughes, a research chemist with Monsanto, carried out the basic research which made it possible to produce a competitively priced biodegradable or soft detergent. This detergent can be successfully and suitably modified by soil bacteria into compounds which do not build up in the ground. The new soft detergents utilize either SAS (sodium alkane sulfonate) or LAS (linear alkylate sulfonate) in place of ABS. If advertising agencies can in some way convince housewives that a greater volume of white suds do not necessarily mean cleaner clothes, the problems created by foam in rivers, underground water, and sewage disposal systems will be greatly alleviated. Actually, suds have little to do with cleaning power. Psychologists inform us that it will be necessary to wage a vigorous campaign on the use of low-suds detergents so that when the housewife opens the door of her washer and sees no suds, she won't feel that she needs to add two more cups of detergent to avoid fear of losing her battle with tattletale grey.

Minerals: Prior to 1890 Great Britain led the world in mining. Between 1800 and 1850 the United States produced from 1% to 2% of the world's minerals. With the advent of increased railroad transportation and a large supply of immigrant labor for mining, the United States competed so successfully in mineral production that the young western giant became the pacesetter for the world production by 1900. In 1912 the United States accounted for 40% of the world's mineral production, whereas Great Britain, the next largest producer, supplied less than 13% of a $4,000,000,000 market. From the following table one can see that the United States was responsible for over one-half of the world's mineral production in 1926.

Value of United States Mining
Compared to That of the Entire World

Year	World Production Millions of dollars	U. S. Production Millions of dollars	U. S. Percentage
1880	1,355	362	41.7
1890	2,163	749	34.7
1900	3,244	1,187	36.6
1910	5,106	2,250	44.1
1920	6,030	3,121	51.8
**1926	7,354	3,777	51.3
1929	8,903	4,110	46.2
*1930	8,190	3,601	44.0
1932	6,288	2,522	40.8
1937	10,015	4,164	41.6
1939	10,035	3,924	39.2

*Hitler's banner begins to flap as Germany's economy begins to flutter.
**World wide depression begins.

During World War II the great industrial nations of the world found it necessary to exploit most energy and mineral sources without regard to long range conservation plans. In the struggle for survival many unwise mining procedures were practiced. Six decades of continuous and drastic depletion, climaxed by the acute demand precipitated by World War II, resulted in the realization by mining companies and governmental officials that some of our mineral supplies were nearly exhausted. Unless sensible conservation practices were introduced the United States would soon find itself in a strategically vulnerable position of dependence upon imports for those materials which are absolutely necessary for national defense. By turning increasingly to foreign markets, in peacetime, by permitting less waste in mining operations by reuse of scrap materials, and by stock piling it is hoped that our industries can become self-sufficient for brief periods of emergency when world imports might not be available.

Atmosphere: Dr. Thomas Aylesworth has stated that air pollution not only kills and maims, but also costs each citizen of the United States $65 per year. The problem is not a new one. By enactment of an ordinance in 1306 the people in the city of London were forbidden to burn coal when Parliament was in session. Pollution has been a problem for centuries, but its effects have been largely limited to densely settled communities. However in the last 150 years the effects of air pollution have substantially damaged art treasures and ancient buildings which had gone almost unchanged for over 2,000 years. When 17 people died and 5,000 became ill during a heavy fog over Donora, Pennsylvania, in 1948, the matter of air pollution was brought vividly to the public's attention. Four years later in 1952 a dense fog settled over London for a week. Before it lifted more than 400 people died as a result of the air pollution in that city.

Research studies show that air pollution may retard plant growth sufficiently to reduce the crop yield by ten per cent. In the Chicago area over 10,000 tons of solid matter and 7,000 tons of gaseous matter are discharged into the atmosphere daily by industry alone. In addition automobiles add thousands of tons of nitrogen oxides, sulfur compounds, aldehydes, lead compounds, organic acids, and carbon monoxide. The sanitation department for the city of Chicago estimates that it has an average of 43 tons per square mile each month of pollution dust fall. What can be done to prevent mankind from poisoning his atmosphere? What special equipment has California forced its automobile owners to purchase to reduce air pollution?

Many of the outstanding scientists in the world feel that mankind's pollution of his environment is the greatest danger to human survival today. The chemical and radioactive pollution of our environment has extremely depressive implications right now, and the cumulative effects of this abuse over several years, cause many scientists to make dire predictions concerning the destiny of human populations.

New and Better Products: Organizations and people who are vitally concerned with mankind's future on this planet are working diligently to use our natural resources sensibly, to find new uses for those materials we already possess in abundance, and to discover and develop varieties of plants and animals that will contribute more efficiently to the world's food supply. In order to appreciate more fully how effective the scientist has been in his endeavors, one needs only to identify the things we have today that did not even exist in marketable amounts prior to World War II. Some of the relatively new products which are extremely valuable are: synthetic fibers e.g. nylon, orlon, dacron, and vinyl; miracle drugs including penicillin, streptomycin, and erythromycin; detergents, jet airplanes, synthetic rubber tires, television, colored film, wash and wear clothing, radar, and lasers.

Today there are in excess of 29,500 tree farms in The United States which cover over 66,000,000 acres. Private companies have planted this vast acreage and are determined to make a profit on their long term investment. Good business men know the profit will be substantially more for those companies which use their raw materials wisely. One large company, which was basically only a lumber and pulp company ten years ago, is making more than 5,000 different products today. At one time a tree was sacrificed and less than 30% of its organic matter was utilized for market. While once only a portion of the main trunk was used to produce timber, today nearly every part of the tree can be used to produce a marketable product. The leaves, twigs, and small branches are ground to produce soil conditioners; the small limbs are turned into shovel and broom handles; larger branches may become posts and pulpwood; the bark is stripped and becomes part of a cattle food supplement; the main trunk is oven treated to volatilize organic materials that are made into salable compounds; slab wood is either burned to provide power for the mill or converted to charcoal; the squared log is cut into commercial lumber; the sawdust is used in producing fiber board; and in case of pine stumps a fragrant oil is extracted to be utilized for cleaning purposes.

The first successful oil well was drilled in Titusville, Pennsylvania in 1859 by Edwin L. Drake. What was orginially termed "Drake's Folley" was of vast significance to mankind, because it proved that it was sound and practical to drill for oil. During the early years of the oil boom fields were exploited and the crude oil was used inefficiently - oftentimes oil refineries turned a waste product called gasoline into streams where it killed fish or caused fires.

Today over 75% of our energy requirements are met by petroleum. The United States has always been the leading oil-producing country in the world and in 1966 produced over 3,000,000,000 barrels of crude oil, 26% of the world's supply.

Crude Oil Production

Country	Millions of Barrels
World	11,900
United States	3,000
U. S. S. R.	1,900
Venezuela	1,200
Saudi Arabia	867
Kuwait	813

The United States has 29 per cent of the refining capacity in the world, but our consumption of 4,300,000,000 barrels of petroleum in 1966 accounted for 35% of the total world demand and necessitated large imports. In order to meet our ever increasing demands, oil companies are developing new methods of tapping oil pools. Through extensive and expensive research oil companies have learned how to utilize their raw materials much more efficiently.

Two new drilling techniques designed to reach oil pools at reduced costs, electridrill and turbodrill, can increase the power available at the bit of the drill. Percussion and flame-jet drilling are based upon new procedures for penetrating rock layers. Oil deposits under the Pacific Ocean have been reached by directional drilling. Since World War II offshore drilling such as is carried on in the Gulf of Mexico off the Louisiana coast has opened many new fields.

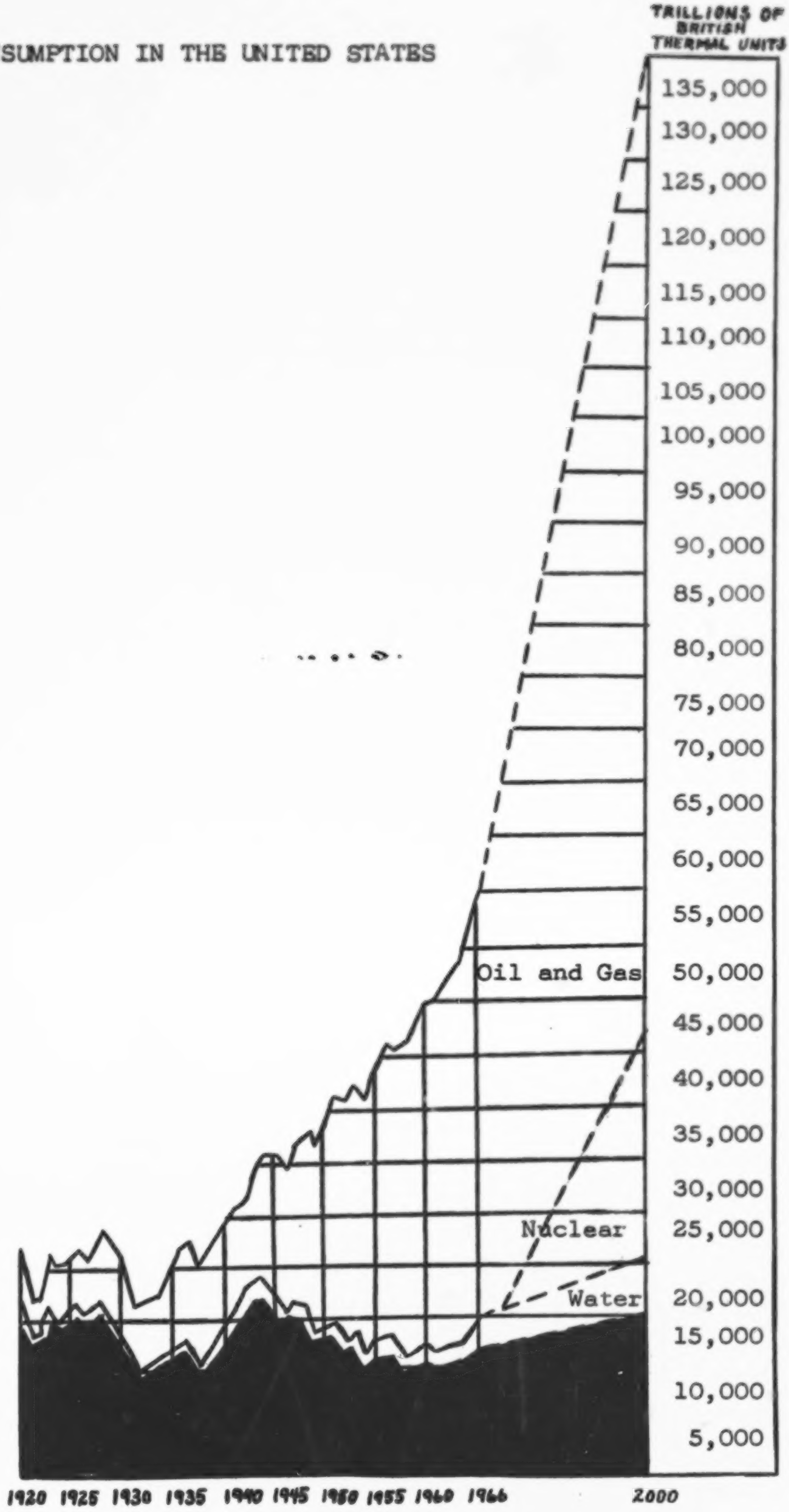
Once a well is found which can produce crude oil in commercial volume an effort is made to keep it producing for as many years as possible. Acidizing and fracturing are two methods used to either open or reopen channels in oil sands thereby enabling petroleum to move toward the bottom of the well. Pressure maintenance of a well may involve water or gas flooding of the reservoir to force oil toward the surface.

Fractional distillation was the only procedure used by refineries to recover gasoline from crude oil until William Burton introduced thermal cracking which improved both the quality and quantity of the gasoline that was obtained from crude oil. At later periods oil companies further improved the percentage yield of gasoline from a barrel of crude oil by catalytic cracking, polymerization, and "sweetening." You may want to read about these processes in the pamphlet Facts About Oil provided free from American Petroleum Institute. If refining techniques had not been improved, it would have been necessary to nearly double our present crude-oil production in order to meet our present demand for gasoline. Without the improved refining techniques gasoline would cost at least twice as much per gallon.

In 1966, five hundred fifty-one petrochemical plants produced 3,000 different chemicals from petroleum and natural gas. The 92 billion pounds of chemicals manufactured from petroleum represents 35% of the total volume of organic chemicals produced in United States. These petrochemical plants consume only 3% of crude oil and natural gas, as raw materials for these organic compounds.

The spectrum of petrochemicals is composed of aliphatic, aromatic, and inorganic compounds. An examination of the following chart clearly indicates that our future is closely tied to a sensible utilization of oil and gas. (See chart on following page)

ENERGY CONSUMPTION IN THE UNITED STATES



The oceans are the greatest reservoir of untapped resources in existence on this planet. It is almost certain that man will turn increasingly to the oceans for water, minerals, and food.

Common methods of converting salt water into fresh water include distillation, freezing, ion filtration and reverse osmosis. All these methods are being used today, but where the primary concern is to obtain fresh water, the last three require less energy expenditure. It is quite likely large amounts of inexpensive energy may become available from nuclear fusion. When this happens man will be able to economically vaporize sea water to provide fresh water and at the same time concentrate as a solid the mineral content of the sea water. The following table indicates the amount, and in some cases the present market value, of the elements found in a cubic mile of sea water.

Amounts of Common Minerals
Available in a $(\text{Mi.})^3$ of Ocean Water

Mineral	Pounds	Retail Market Value (Purified)
Boron	43,400,000	
Bromine	613,000,000	
Calcium	3,870,000,000	
Carbon	364,000,000	
Chlorine	179,000,000,000	134,000,000,000
Copper	28,300	
Fluorine	12,200,000	
Gold	472	264,000

Minerals Table Continued

Mineral	Pounds	Retail Market Value (Purified)
Hydrogen	1,020,000,000,000	
Iodine	472,000	2,910,000
Iron	47,200	
Magnesium	12,000,000,000	37,700,000
Mercury	283	
Nickel	6,600	
Nitrogen	1,720,000	
Oxygen	8,080,000,000,000	4,040,000,000,000
Phosphorus	660,000	5,480,000,000
Potassium	3,580,000,000	86,000,000,000
Silver	2,830	181,000
Sodium	99,700,000,000	307,000,000,000
Sulfur	8,340,000,000	3,160,000,000
Tungsten	944	
Uranium	28,300	
Zinc	94,400	110,000

A careful examination of the table will show that the retail market value of only twenty-four of the more than eighty elements found in ocean water, is far greater than the gross national product of the United States. The retail sale of the sodium alone in a cubic mile of sea water would suffice to pay off our national debt. The oxygen bound up chemically in 2,140 mi.^{3} of ocean water is about the same amount as is found in our atmosphere. If the energy available from nuclear fission of the trillion pounds of hydrogen in a cubic mile of sea water can be unleashed, it will provide a far greater supply of energy than all that mankind has produced up until this time. Is this ample justification for making an all out effort toward realization of this potential?

If the sea has sufficient water, air, and minerals to meet man's future requirements, can it also supply him with food? It is quite likely that man will depend primarily on the oceans for his food. The four major groups of "seaweeds" or marine algae are red algae (Rhodophyto), brown algae (Phaeophyta), green algae (Chlorophyta), and blue-green algae (Myxophyta). While thousands of species have been identified, only a dozen or so species are used commercially in this country. The oriental nations use certain "seaweeds" extensively for food and find "seaweeds" to be valuable sources of vitamins, minerals, carbohydrates, and proteins.

Giant beds of kelp, a brown algae "seaweed" are found along our entire Pacific coast and off the coast of Maine. A mowing barge can harvest as much as 300 tons of kelp a day. The cutting bar which is set four feet beneath the surface of the water enables the reaper to remove the dense upper mat thereby exposing the balance of the plant to more sunlight. The exposure stimulates the plant to greater growth, and with a few weeks new leafy stems 20 feet in length are again ready for harvesting. These plants grow all year long and there is no danger of depletion.

Irish moss, a red algae, is obtained along our North Atlantic Coast. It grows from just above water level to a depth of 20 feet and is relatively easy to harvest. A man, either picking by hand or using a long-handled rake with closely set teeth, can harvest from 800 to 1,000 pounds in less than 6 hours. The Irish moss is used to bake a pudding like dessert. Many of the European nations use "seaweeds" for feeding livestock thereby freeing productive farmland to produce food for people.

It will take several years for people to adjust to the new kinds of foodstuffs. An examination of the following tables shows the common foods of today are similar to those man has eaten for centuries.

Old World Plants Cultivated
for over 4,000 Years

apple
banana
barley
cabbage
fig
grape
olive
onion
peach
pear
rice
tea
watermelon
turnip
wheat

Old World Plants Cultivated
for over 2,000 Years

carrot
cherry
beet
cotton
lettuce
oats
orange
plum
radish
rye
walnut
yam
sugar cane

Old World Species Cultivated
for less than 2,000 Years

buckwheat
coffee
muskmelon
okra
raspberry
strawberry
rhubarb
currant

New World Species Cultivated
More Than 2,000 Years

kidney bean
maize
sweet potato
tobacco

New World Species Cultivated
Before Time of Columbus

guava
avacado
peanut
pineapple
potato
pumpkin
red pepper
squash
tomato
vanilla

New World Species Cultivated
Since Time of Columbus

blackberry
black walnut
blueberry
cranberry
dewberry
pecan
persimmon
plum
gooseberry
strawberry

There are at least five things man can do to improve his food supply: (1) increase the yield of existing plants and animals; (2) begin to use those species of plants and animals for food that are now utilized in limited areas of the world; (3) to create food from fossil fuels; (4) develop entirely new plants and animals; and (5) develop new products both from plants and animals with established value and from those presently with no known value. The last method presents a vibrant argument for the conservation of all present species.

Man has been spectacularly successful in his efforts to increase yields. The Irish potato, Solanum tuberosum, was introduced into Europe about 1580 by the Spaniards. About 90% of the crop is cultivated in Europe today, but potatoes are grown more universally than any other crop. Between 1936 and 1948 The United States doubled its yield of potatoes per acre by use of fertilizer and better seed. Today one may raise 300 bushels of potatoes on an acre which would produce only 80 bushels before 1900. About 60% of the corn produced in the world is raised in the Corn Belt of The United States which is about 900 miles long and from 150 to 300 miles wide. Locate it on a map. This belt has almost ideal conditions for cultivating corn. What are these conditions? Largely by planting hybrid corn The United States was able to increase its per acre yield of corn by 67%. In the year 1950 The United States was averaging 25 bushels of corn per acre, and today the national average is over 60 bushels per acre. Some states produce an average of more than 80 bushels per acre and some farms may produce 300 bushels per acre. It takes about 25 bushels of corn per acre to pay the costs of each acre planted, therefore an increase from 30 to 35 bushels per acre may mean a doubling of the farmer's profit. Consult an encyclopedia to learn how the plant breeder produces hybrid corn.

Were you grieved because John the Baptist ate locusts? He was in fact consuming hard sugary beans which were found in the pods one finds in a Carob tree. This is a standard article of food in many Mediterranean countries and can be bought almost any day of the year from pushcart vendors on the lower east side of Manhattan Island. These trees thrive on rocky hillsides where the rainfall is less than 10 inches per year. Production is as great if not greater per acre than Indian corn, and "locusts" sell for about the same price as corn. The Keawe tree was first brought to the Hawaiian Islands from Chile in 1826. Since that time it has become the dominant plant on much of the land on hilly slopes which has less than 20 inches of rainfall per year. The food value provided by the Keawe bean per acre of ground is equivalent to what one would receive if he were able to produce 333 bushels of barley per acre (average production of barley is less than 21 bushels per acre). Stock which is pastured on Keawe groves will make from 3 to 4 times more meat gain per acre than stock fed on an equal area of alfalfa or corn in the richest farmland of the midwest.

Man has been endeavoring to improve his plant and animal food sources for thousands of years by selective breeding. For over 50 years man has been trying to improve plants and animals by scientific inbreeding and crossbreeding. Today man is actively involved in trying to expedite the creation of valuable mutations by subjecting plants to doses of radioactivity. Man can create as many mutations in a day now as nature has been able to create in 1,000 years. By selecting those mutations which have desirable properties, man has been able to greatly increase the productivity of antibiotics. Other effective measures that man has taken to increase his food supply will be discussed in Chapter XI.

Man alone among living organisms was created intelligent. If there is any purpose or direction for life on this planet, it is man's responsibility to direct the interweaving of the web of life toward achieving that purpose. Man is a social animal and he will be able to provide this direction only if there is concentrated cooperation and support for the welfare of all people. The responsibility for cooperation rests upon the individual shoulders of each man, woman, or child on this planet. What have you learned from studying this chapter? Is there anything you can do to see that our natural resources are utilized intelligently?

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CHAPTER VII

HOW ARE ALL LIVING THINGS ALIKE?

Objectives

To find out--

1. What is protoplasm?
2. What is the cell theory?
3. How are cells organized in living things?
4. How are living things interdependent?

All living things are made of protoplasm.

What is protoplasm?

Elements contained in some form of protoplasm:

Carbon
Hydrogen
Oxygen
Nitrogen
Phosphorus
Potassium
Sulfur
Calcium
Iron
Magnesium
Boron
Zinc
Aluminum
Manganese
Molybdenum
Chlorine
Copper
Sodium
Silicon

All living things are composed of cells.

The cell is the basic unit of structure and function of all living things.

Factors concerning the cell:

1. Size

Among the smallest are the Rickettsia, ie. the Rickettsia species that causes typhus is about 0.5 microns long and 0.2 microns wide.

The smallest human cell is 4 microns in diameter--1/6250 inch. (A micron = 1/25,000 of an inch) The average human cell is 50 to 100 microns or about 1/250 of an inch in diameter. The yolk of an egg is one cell. It is a very large cell. The ostrich egg may be the largest of cells in volume. It has a diameter of about 8 cm. or approximately 3 inches. The volume of the ostrich egg is said to be nearly 15 quadrillion times that of a Rickettsia cell.

Experience:

Obtain the yolk of an egg and show that it is surrounded by a membrane.

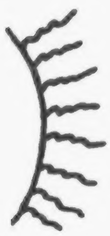
Show some prepared slides of some small cells.

2. Shape of cells

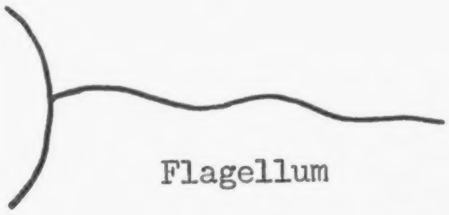
Flat, oval, spiral and spherical cells occur in nature.

3. Surface or membrane

Most membranes are smooth; plant cells have cell walls, animal cells have only cell membranes; some cells have cilia and flagella; some cells exist in capsules; encapsulated bacteria are harder to kill.



Cilia



Flagellum

Experiment:

Look at onion cells under the microscope.

Materials needed: Onion, ink or blue violet water.

Process: 1. Peel a very thin layer of tissue from the onion.

2. Place it on the slide.

3. Put a few drops of ink on the onion with the cover slip, observe under a microscope, and point out a few parts of the cell at this time.

Look at some cork cells.

Materials needed: Cork bottle stopper, razor blade.

Process: Slice the cork into very thin layers and observe under a microscope.

Question: What is the difference in the cork cells and the onion cells?

Answer: The cork cells are dead and we are really seeing only cell walls. (We see all the visible parts of a cell in an onion cell since it is still living.)

What are the functional parts of the cell?

1. Nucleus--usually a circular structure found in the center of the cell. It contains the DNA and it controls the activities of the cell. If the nucleus were removed from a cell, the cell would not engage in cell division and it would ultimately die.

2. Cytoplasm--is the semiliquid surrounding the nucleus and extends to the cell membrane. The cytoplasm contains RNA. RNA is the messenger that carries the blueprint given it by DNA to sites in the cytoplasm where the blueprint is used to produce the enzymes that regulate the changing activities of the cell. Mitochondria, vacuoles, and plastids are also found in the cytoplasm.

3. Mitochondria--are rod-shaped structures found in all cells. They are known as the power houses of the cell. Food is oxidized or converted to energy in the mitochondria.

4. Vacuoles--are the storehouses of the cell. They store water, food, fats, and oils.

5. Plastids--the structures found only in plant cells and the cells of the protists. The plastids may contain chlorophyll or other pigments. They also may store starch.

6. Cell membrane--is the structure completely surrounding the cell.

7. Cell wall--is the structure found only around the outside of plant cell. The cell wall is nonliving and is thought to enclose the living cell membrane.

How cells are organized in living things:

Cells are the basic unit of structure and function of all living things. One-celled organisms carry on the life processes with the single cell. Many celled organisms have specialized cells organized to perform a specific function or functions.

More complex organization proceeds from cells--to tissues--to organs--to organ systems within complex organisms. Tissues are a group of cells which perform a specific function. Organs are a group of tissues which have similar appearance and function. Organ systems are organs that function together to form a life process.

Kinds of tissue in animals:

1. Epithelial--covering tissue found on the inside and outside of the body.
2. Muscle tissue--tissues specialized for contraction.

   The three kinds:

   a. Skeletal muscles--are those muscles which actuate skeletal movement. These multi-nucleated fibers, with alternate light and dark transverse striations, are capable of quick response to the conscious direction of the owner;

   b. Smooth muscles (visceral muscles)--are the simplest type of muscle composed of elongated single nucleated cells that contract slowly but are capable of remaining contracted for long periods of time. Other than serving as the contractive force in the respiratory, digestive, circulatory, and excretory systems, these muscles are usually arranged in sheet-like layers. The control of these muscles is involuntary;

   c. Cardiac muscles (heart muscles)--have the appearance of skeletal muscles but are involuntarily controlled.
3. Nerve tissue--receives stimuli and causes a reflex or response.
4. Connective tissue--serves to connect the different parts of our body.
5. Supporting tissue--supports our body.

   a. cartilage
   b. bone

Kinds of plant tissues:

1. Epithelial--covers the outside of the plants;
2. Embryonic--found at the tips of roots, and in stems and leaves. It gives rise to all new plant tissue.
3. Supporting--heavier or stronger tissues used to keep plants in position.

4. Conducting--pathway for water and dissolved materials to move up and down the plant.

Kinds of organ systems:

1. Skeletal
2. Muscular
3. Digestive
4. Respiratory
5. Circulatory
6. Excretory
7. Nervous
8. Endocrine
9. Reproductive

Respiration:

All living things engage in the degradation of energy levels of compounds in order to provide energy for the support of life. Respiration is one of several processes that takes place within individual cells. Through this process oxygen is united with a carbohydrate to yield water, carbon dioxide and energy. The energy is trapped by biochemical means to use to meet the energy requirements of the cell.

Experiment:

> To prove H_2O is present as a product when O_2 is combined with an organic product, use a few drops of cooking oil on a tin plate. Invert a mayonnaise jar over the oil. With a Bunsen burner heat the oil until it burns. Moisture should condense on the jar thus proving the presence of H_2O as a combustion product.

Experience:

> To prove that CO_2 is a product: Knowing that the candle wax (a carbohydrate) is being united with oxygen (burning), place $\frac{1}{2}$ of a petri dish filled with limewater under a bell jar with several lighted candles. Also place $\frac{1}{2}$ of a petri dish filled with limewater under another bell jar without burning candles. If a white precipitate is formed it is due to the presence of CO_2 because--

$$\underset{\text{limewater}}{Ca\,(OH)_2} + CO_2 \;\_\_\_\_\; \underset{\substack{\text{a white}\\ \text{precipitate}}}{CaCO_3} + H_2O$$

That energy is a product of respiration can readily be observed in warm-blooded animals, where it is manifested by the heat their bodies give off.

Movement in living organisms will also demonstrate the expenditure of energy.

Suggested Activities: (Cheek Cells)

Reach inside your mouth and scrape some cells from inside your cheek with the flat end of a tooth pick; spread the cells over a clean slide gently, add several drops of ink, cover with a cover slip and examine with the low power of a microscope.

(Muscle Cells)

Pull apart a small piece of beef with two pins; stain with methylene blue and cover with cover slip, then examine under the microscope.

(Cartilage)

Slice a small piece of cartilage from the end of a bone with a sharp razor. Add a stain and examine with a microscope.

(Organ Systems)

Dissect a frog by making an incision the length of the central body wall. Observe and identify the stomach, intestines, liver, gall bladder, lungs and kidneys. Trace the respiratory system by blowing air into the frog's mouth with a straw.

(Tissues)

Demonstrate what tissues are like by means of charts, diagrams, pictures or with the aid of the microscope. Show prepared slides of the animal tissues. Have the pupils identify each tissue, giving its function or functions and relating its structure to its functions.

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I. The Interdependence of Living Things

A. Plants and animals live together.

1. All animals depend either directly or indirectly on plants for food.

2. Many plants depend on animals for help in reproduction and the scattering of seeds and for replenishing the supply of carbon dioxide in the air.

B. Some animals depend on animals of their own kind.

1. Beavers--work as a united group cutting trees and building dams.

2. Bees--thousands live together as a colony.

a. Workers--gather raw materials to make honey and the other foods, produce wax, clean and ventilate the beehive, nurse the young and guard the beehive against enemies.

b. Drones--mate with queen to produce new bees.

c. Queen--spends her life laying eggs.

C. Some animals depend on other species of animals.

1. Termite--microscopic animals in digestive tract of the termite perform the process of digestion of wood particles which the termite cannot digest.

2. Ant and Aphid--Aphid sucks juices from plants and secretes sweet fluid desired by ants, in turn the ant protects the aphid and cares for the aphid's young eggs.

D. Animals depend on plants--plants are the ultimate source of food for all animals. Plants remove carbon dioxide from the air and release oxygen.

E. Some plants help other plants.

1. Legumes and nitrogen fixing bacteria--the nitrogen fixing bacteria are microscopic plants that live in swellings on the roots of legumes and convert nitrogen from the air into nitrogen compounds usable by their host plant and others.

2. Lichen--consists of an algae and a fungus living together; the alga manufactures food which the fungus uses; the fungus absorbs water for use by the alga.

F. Some plants live on dead organisms.

1. Bacteria--the bacteria of decay live on dead organisms or waste products of living animals converting dead or waste materials into substances that can be used by other living plants.

2. Other fungi--bracket fungi are found growing on decaying tree trunks; mushrooms are found on dead tree trunks and on damp soil high in organic materials.

G. Plants and animals that are parasites--some plants and animals obtain their food by living at the expense of some other living organisms, ie. mistletoe, ticks, and leeches.

H. Food chains

1. Green plants are the primary food producers.

2. All organisms live directly or indirectly on plants.

II. Energy of Life from Photosynthesis (defined not to include Bacterial Photosynthesis or Chemosynthesis)

A. Discoveries that have led to present concepts of photosynthesis

1. Priestley and the liberation of oxygen by plants.

2. Jan Ingen-Hausz (light necessary to bring about the restoring of bad air)

3. Oxygen from the breakdown of H_2O by Van Neil.

4. Chlorophyll--the compound that first traps the sun's energy by Daniel Arnon, J. A. Bassham, Eugene Rabinowitch, and Govindjee.

B. The end products of Photosynthesis

1. Glucose

2. Oxygen

III. What Things are Necessary for Photosynthesis to Take Place

A. Chlorophyll

B. Raw materials, carbon dioxide, and water

C. Sunlight

D. Catalysts

Suggested Activities:

Wash soil away from the roots of a potted pea plant to expose nitrogen fixing bacteria nodules. Break open a nodule and examine it under the microscope.

Bisect a termite longitudinally and immerse the cut half in a drop of water on a slide. Remove the termite and examine the slice under a microscope.

Pose some open-end questions such as: What difficulties would you foresee in trying to test whether or not a plant must have carbon dioxide for photosynthesis?

References:

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CHAPTER VIII

HOW ARE LIVING THINGS DIFFERENT?

Objectives

To seek to answer--

1. How are all living things classified?
2. How organisms adapt to their environment by genetic changes?

Most of us learned about diversification in the animal and plant kingdoms before we were two years old. Dog, cat, tree and flowers are among the first verbal terms we used to describe living forms. Even then we were placing living things in different categories. We can recognize that this was a developing classification system of our own.

Suppose you were taking a midsummer vacation trip through upstate New York and you became curious about the names of some of the wild flowers by the roadway. You might purchase a paperback on wild flowers such as A Pocket Guide to Wild Flowers by Samuel Gottscho. Gottschos' Guide has the different flowers separated according to color so that when you see a blue flower you thumb through the blue flowers until you find one like the one beside the road. Likewise, if you discovered an unknown red flower you would flip through the red flower section until you found one like it.

There are lists of flowers that bloom each month of the year and keys to show what type of landscape the flower can be expected to grow in. These methods of classification can provide a lot of information quickly. Since the method of classification does not in any way depend on how the flowers may be related genetically to one another, it is called an artificial system. It is a method designed for the user's convenience and it can be both fun and useful on a beginner's level.

Of course, whenever we start giving names to plants and animals we must recognize that names are often not the same for different languages and indeed they even change from one part of the country to another. Common names are so unreliable that what is called a "buttercup" by some East Texans is really an "evening primrose." About 1750 a Swedish naturalist, Carl von Linne (Linnaeus) developed a system for naming plants and animals that is the same the world over. Linnaeus, as he is known, used Latin as the language for recording the genus and species name and description of each plant and animal known.

If Linnaeus were to classify an evening primrose, he would try to trace it back through genetically related groupings until he placed it nearest its closest relatives. This is called a phylogenetic classification system. The first decision would be that our pink evening primrose belongs to the Plant Kingdom rather than the Animal Kingdom. It has true vascular (conducting) tissue so it would be in Phylum Tracheophyta and Subphylum Pteropsida. It is a flowering plant so it would be in the Class Angiospermae. Its seed bears two seed leaves (cotyledons) so it would be in the Subclass Dicotyledoneae. Its flower of four petals is radially symetrical and bisexual with an inferior ovary bearing united carpels, placing it in the Order Myrtaceae. Because of its opposite leaves, flower parts in fours and its fruits being borne in an inferior united capsule it is placed in the Family Onagraceae. Depending on even more detailed differences our pink evening primrose is placed in the Genus *Oenothera* and the Species *speciosa* so that its scientific name is *Oenothera speciosa*.

This binomial system of nomenclature was first published by Linnaeus in his *Species Plantarum* (describing plants) in 1753 and his *Systema Naturae* (describing animals) in 1758. The following classification of man may help review the levels of choice established by Linnaeus.

MAN

Kingdom - Animal
Phylum - Chordata
Subphylum - Vertebrata
Class - Mammalia
Order - Primates
Family - Hominidae
Genus - Homo
Species - sapiens

The scientific name for man is *Homo sapiens* which means wise man.

As scientists have learned more about the true relationships between species the placement and names have been altered, but the system has provided names stabilized the world over while showing relationships as they are known. In a naturalist role, Charles Darwin, starting in 1831, took a five year cruise around the world collecting specimens and observing the variation and the interaction between living things in diverse settings.

4 mig

He observed that no two individual plants or animals, even within the same species, are exactly identical -- there is seemingly continuous variation in offspring. As he compared species in different parts of the world he was especially impressed by the fact that island forms were similar to those on the mainland yet not identical to them. He also found that species from two adjacent land masses showed closer similarity than those separated by much greater distances. Why did this pattern occur again and again?

Darwin observed that each generation of many plants and animals produced far more than a replacement number of progeny. And yet with all species in an area overproducing offspring, the resulting new population was about the same in numbers for each species as was the parent population.

Darwin hypothesized that since a given population usually reproduces many more offspring than can be supported in the region occupied, there must be a struggle for survival between individual offspring. Through the struggle for survival only those individuals possessing variations better adapting them for life in that ecological setting survive. In this way a natural selection takes place so that the unfit do not survive. The variations representing better adaptation not only survive but are passed on to the next generations by heredity and thus, eventually, give rise to new species.

Although we still have much to learn about the mechanisms through which species undergo change, Darwin's observations and conclusions have been an important bench mark in man's understanding of the development of new species (evolution). Even though Darwin found little change in population numbers from generation to generation for a given area, we know that there are changes in the numbers daily. Within the overall balance of numbers sometimes referred to as a balance in nature, fluctuations occur in both numbers of each species and in the ratio of each species to the total population. As long as these changes occur in a cycle and return to about the same numbers, the changes are considered part of a dynamic balance or dynamic equalibrium. Usually, genetic changes giving a species an advantage are offset by corresponding changes in opposing species thus restoring the balance. When moose numbers on Isle Royale are reduced the number of wolves are reduced. Conversely when moose numbers on Isle Royale are increased the number of wolves are increased. However, physical changes in the environment that changes the ecological setting such as fire, volcanic erruption, cultivation, constant smoke, polluted water or man, produce corresponding changes which may destroy the effectiveness of the natural balance and cause a sudden expansion of an immigrating species. Man killed the predators for deer in Michigan a few years ago and did not allow hunting. The resulting growth in deer numbers was so great that they became over-populated in the state. Great numbers starved during the winter months.

Arbitrary changes made by man should be planned and researched well to determine the lasting effect that such environmental modifications will have.

Evaluation

Review literature on Lemmings and present hypotheses to explain why they move in masses to the sea. What is the effect of the mass deaths on the dynamic balance in their area?

Present evidence for or against including rabbits in the rodent order. How do their teeth compare with animals known as rodents?

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CHAPTER IX

How can an understanding of life science help me to live a more effective and fuller life?

Objectives

1. What can I discover when we explore nature's relationships to man?
2. What is the value I should place on our individual and collective natural resources?
3. What are mankind's problems concerning food and energy?
4. What are the contributions science has made to modern living today and what are some of the challenging problems still unsolved?

BIOSPHERE

Introduction

All the plants and animals of the earth live together in communities. A single community is made up of many species, all living together in the give-and-take of their interrelationships. The plants and animals react to each other and also to their common environment. The living things of a community are dependent upon one another. Found within the communities of the biosphere are unfolding phenomena of birth, competitive struggle, survival, death, and new birth. All the plants and animals of the world make up the biosphere. Each plant and animal has some relationship to every other plant and animal. One of the tiniest of microbes, for example, is indirectly responsible for the survival of several species of multicelled vertebrates. All living things are bound together into one massive unit--the biosphere.

There are myriads of living things within the biosphere. Yet, no living organism is completely independent. Every plant and animal is dependent in some way upon other living things. The relationships are not always direct. In fact, there is an interweaving of many indirect relationships. The biosphere is a kaleidoscope of cycles, chains, and processes. This highest level of organization is a magnificent web of life.

The living things within the biosphere can be placed into one of two broad subdivisions. The living things can be classified as either producers or consumers.

Layers of Life

A. The biosphere consists of - the layer of living things spanning the earth from within its crust to its upper atmosphere.

The biosphere can be broken into three major fields of study:

1. The atmosphere is the ocean of air surrounding the earth. The atmosphere is the continuous envelope of gases that surrounds both the lithosphere and hydrosphere. The atmosphere extends into space hundreds of miles above the earth's surface.
2. The hydrosphere is the part of the earth that is covered by water. The oceans now occupy nearly 140,000,000 square miles of the earth's surface. Smaller bodies of water form inland seas, lakes, and streams on the 57,000,000 square miles of continents and islands. Additional water fills openings in the soil and rock beneath the surface. Taken all together the earth's waters are known as its hydrosphere. But since the hydrosphere is a surface covering, rather than a sphere, it is better described as an incomplete envelope of water.
3. The lithosphere is the solid part of the earth. The earth's total area of 197,000,000 square miles is wrinkled into a rough pattern by great highlands and deep basins.

A producer is a manufacturer. The producer makes something. The most important producer of the biosphere is the green plant. Through a process called photosynthesis green plants make food for the biosphere. In this process the plants take in carbon dioxide, water, and the energy from sunlight to produce Glucose and Oxygen. Most living organisms of the biosphere feed through this process. Green plants, alone among living things, carry on photosynthesis.

A consumer is a user. The consumer uses the things the manufacturer produces. Animals are the consumers. The feed upon the plants or upon other animals. Without green plants to make food, animals could never survive.

There are three major types of producers. They are Herbivorous, Carnivorous, and Omnivorous.

A. The diet of a herbivore consists wholly of plant life. These animals feed on grasses, grains, roots, leaves, and stalks. Some herbivores are large and some are small. There is a wide range of sizes among herbivores stretching from a newly hatched snail to a mighty sperm whale.

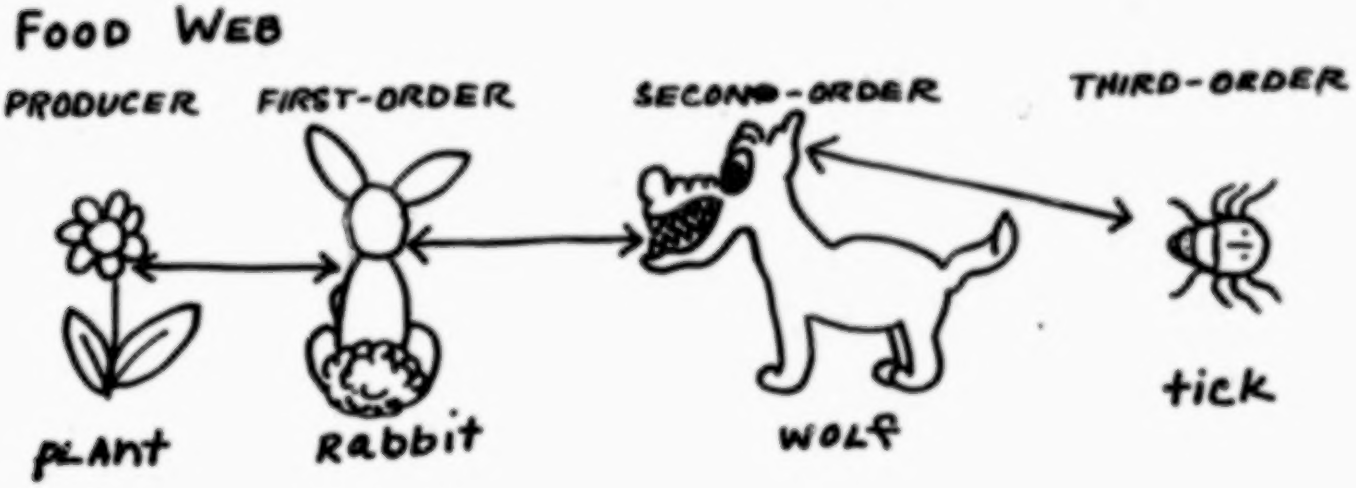
B. The carnivore is a flesheater. They are animals that eat other animals. Many familiar carnivores live on land, but there are also many carnivores among aquatic animals. Most carnivores have teeth that are suitable for tearing and chewing flesh.

C. The omnivore is an animal that eats both plants and animals. Some of our most familiar animals are omnivores. Bears, raccoons, opossums, and skunks thrive on a diet of woodland fruits and berries. They also eat insects and frequently pounce upon mice, frogs, and lizards, and other small animals.

Biologists have grouped animals in consumer levels, or orders. Herbivores are FIRST-ORDER consumers because they feed directly on the plants. A carnivore is designated a SECOND-ORDER consumer, because it feeds on first-order consumers. The THIRD-ORDER consumer, such as a meat eating carnivore, may come along and capture a weaker second-order consumer.

The first, second, and third-order consumers form a FOOD WEB. The food web unfolds as a first-order consumer, eats a plant and then is captured by a second-order consumer. The food web is one of the most important aspects of a plant and animal community.

A food web helps to maintain a BALANCE IN NATURE. That is, it prevents one species from crowding out other living things. Consider rabbits, for example. Rabbits multiply in great numbers, without second-order consumers on hand to deplete their number, they soon would take over a community.



PARASITES, DECOMPOSERS, AND SCAVENGERS

A. Many animals obtain their energy at the expense of another living organism. Such animals are known as parasites. The animal that is lived upon is referred to as the HOST of the parasite. Parasites can be found in every community of living organisms. Both plants and animals are fed upon as hosts.

B. There is a group of living organisms that decompose the remains of the organisms that die. This special group of consumers are known as decomposers.

To decompose is to break something apart. The decomposers do just that. They break down the remains of dead organisms. They decompose the dead bodies into simple substances that can be used by plants. This is another example of how organisms are helpful to each other.

C. A scavenger performs a clean-up task. The scavenger within the animal kingdom finds dead animals to eat rather than capturing and killing his own victims. A vulture is a scavenger. A few other scavengers are: ants, termites, earthworms, hermit crabs, and burying beetles.

There are several important cycles within the biosphere. Among the essential cycles are the carbon cycle, the water cycle, the calcium cycle, and the nitrogen cycle.

Communities Found Within the Biosphere

There are many kinds of plant-animal communities. All the various communities can be grouped into two general divisions. These two broad divisions consist of aquatic communities and terrestrial communities.

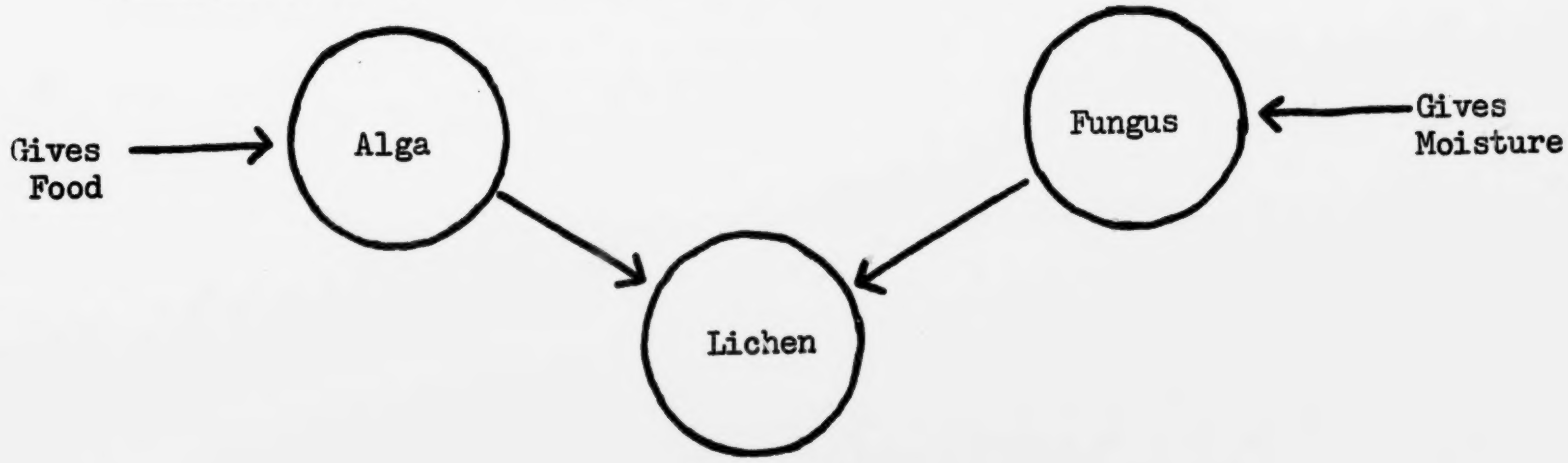
A. An aquatic community consists of plants and animals living in water or near water. Some aquatic communities are found in the ocean. The ocean communities are referred to as MARINE COMMUNITIES. Other aquatic communities are found in fresh water. The freshwater communities exist in and near swamps, bogs, puddles, ponds, lakes, rivers, and streams.

B. A terrestrial community is a community of plants and animals that live on land. Terrestrial communities can be found in or on all land masses except the tips of the tallest mountains, the active parts of volcanoes, and the most severe portions of the world's most arid deserts.

Relationships Within the Biosphere

A. Mutualism is a relationship in which two organisms share in a living arrangement that accrues to the advantage of both. There are many examples of mutualism found within the biosphere. When an alga and a fungus join to form a lichen, a state of mutualism is established. The alga is a green plant; it is a producer. The other part of the lichen is a fungus. A fungus is a parasite. It lives off of a producer. Thus, in the form of a lichen, the alga and fungus have entered into an association that is beneficial to each.

The fungus of a lichen benefits from the food-making ability of the alga. The fungus gets its food from the alga. As a producer, the alga is also indebted to the fungus. Without the fungus, the alga could not live in the places where lichens are found. The fungus adds enough moisture to the plant to keep the alga from dying.



Two organisms have joined for the benefit of both.

B. Another form of association in which two organisms join is COMMENSALISM. Commensalism is a one-sided relationship. One organism attaches itself to another organism. Although the two organisms live together, only one of them benefits from the association. The attached organism is known as a commensal.

Some sea animals are commensals. For example, the barnacle attaches itself to a whale. The barnacle gets a free ride in its search for food.

In this case the barnacle is a commensal.

Plants, too, practice commensalism. Spanish moss, for example, grows on trees instead of in soil. Such plants as Spanish moss are known as EPIPHYTES. Epiphytes are not parasites. They make their own food. They attach themselves to other plants only for support and anchorage. This relationship is unlikely to be harmful to the carrying or supporting organism.

C. Another relationship between a "host" and a "guest" is known as parasitism. The plant or animal preying upon the host is known as a parasite. A parasite lives in or on the body of a larger organism.

There are all sorts of gradations in the manner and extent that prarsites exist at the expense of their host. Some parasites depend completely upon the host organism. Others derive only a part of their nourishment from the living thing to which they are attached. A parasite can kill its host. Would you say such a parasite was operating successfully. In some instances, a parasite is harmful but not fatal.

D. A community of living things is a competitive world. COMPETITION is a widespread relationship in the biosphere. Plants compete against each other for water and sunshine. Animals, too, are rivals. One animal competes against another in the constant search for food. Animals also compete for places to live. Birds sing in the morning to warn away competitors for their claimed feeding and rearing area. Many young birds must be fed every 15 to 30 minutes or they die. If competitors were tolerated, the young of both claimholder and competitor would die because food could not be obtained fast enough to meet the needs of the young.

E. Exploitation is another relationship found within the biosphere. To exploit is to use someone else for one's own advantage. A certain species of ants, for example, maintains slave ants to do all the labor in the colony. The captured ants gather food and build the nest for the master ants. Master ants sometimes collect the cocoons of other ants. When the cocoons hatch, the new born ants join the master colony as workers and live their lives out in slavery.

I. Land Communities and Their Changes

Locate a vacant lot in your community for a study of ecological event known as succession. If there is no vacant lot, obtain the permission of a landowner to use a plot for your investigation. A three-foot square of ground is all you need. Perhaps you can set aside a portion of the school ground.

Strip your plot of all its vegetation. Remove all the weeds and grass. Use a spade to turn rocks in the soil. Do not disturb any tree roots that you might uncover.

Begin your investigation with a detailed observation of the barren plot. What is the condition of the soil? Is there water nearby? Are animals likely to frequent the area? Is the plot sheltered from squalls and crosswinds? Or is it in the open area? Are there trees and other plants nearby? Record your observations in your science notebook.

Examine this plot at least once a week throughout the remainder of the school year. Look for changes. Are plants beginning to grow? Are there signs of erosion? Is there a growing population of insects? Are there signs of other animals? Does the weather bring about changes?

Record your weekly observations. As the plot changes from week to week, compare its appearance and condition with the nature of the plot at the beginning of your investigation.

II. Changes Found in Water Communities

Visit a pond your community over a period of one month. On your first visit examine the physical features of the pond. How big is the pond? What is the depth of the water? Is it sheltered? Does the sun shine on a portion of the pond?

Make a list of the living things you observe in the pond community. Is there a variety of plants and animals? How many different animal populations are represented? What plants are growing on the bank of the pond? Do any of the plants grow in the water?

Keep a record of the plant and animal relationships that you observe. Is there evidence that the plants help the animals? In what way do the animals help the plants? Are there changes in the plant life from week to week? Are there changes in the animal life? Can you observe the growth and development of living things?

Put a list of your observations on a classroom wall chart. Have places in your chart for each plant and animal within the pond community. Note the growth of new plants and the birth of new animals.

HABITAT

I. Definition

The natural environment in which a plant or animal is usually found.

II. Factors Affecting Habitats

Temperature, light, moisture, food, density of population, presence or absence of other living things.

III. Major Types of Land Habitats

1. Grasslands located in both tropical and temperate zones where there is yearly rainfall average of 10 to 30 inches. Even though this is not sufficient rainfall for the growth of large trees, it is adequate for growth of grasses and small herbs. Other names given to grasslands are prairies in Western United States, steppes in Europe, pampas in Argentina, and velds in South Africa. Each one of these has its own characteristics depending upon the soil, and the amount of and frequency of rainfall. The Great Plains grasslands, where bison, antelope, and many herbivores roamed, have been plowed under and are today a region for growing corn and wheat. Large herds of antelope, gazelles, zebras, and giraffes are found in the grasslands of Africa. Rodents, insects, locusts, and burrowing animals are also found in the grasslands.

2. Deserts - Rainfall is usually less than 10 inches a year. Evaporation is high due to the excessive heat and high winds. Since there is little moisture, the sun heats the earth quickly, but this dry climate allows the earth to cool extremely fast; therefore the days are hot and the nights are cold.

Some characteristics of desert plants are: Dense woody structures, thorns, enlarged green stems and waxy leaves, if leaves are present. The large green stems and few leaves enable the plants to conserve water. Roots are numerous and sometimes very deep. Well developed root systems enable desert plants to absorb what little water may fall.

The Joshua tree and cactus are typical desert plants in some parts of the American west. Animals of the desert are those adapted to high heat and little water. Kangaroo rats, lizards, snakes, gazelles, camels, and snails are a few examples.

Camels have no special organ for storing water, but their bodies are adapted to conserving water. Their body temperature drops to 93°F at night. Water is conserved at night since the body processes function at a slower rate. Camels do not begin to perspire until their temperature reaches 105°F.

3. Tundra - A vast treeless plain encircling the Arctic Ocean. Winters with cold temperatures and long dark nights alternate with summers and almost continuous daylight. Most of the moisture is from the snow. The ground is permanently frozen except for the top layer during the short growing season. The top foot or so of soil thaws during the summer yielding a great deal of moisture to the soil. Any organism living there must be able to withstand sudden changes in temperature as there may be several frosts during the two month growing season. The main forms of plant life are mosses and lichens. Some flowering herbs displaying beautiful colors are also found in the tundra. In the summer, waterfowl and other birds come to the tundra to nest. Though most of the summer organisms migrate to the tundra, the snowshoe rabbit, the

arctic fox, and the ptarmigan are permanent residents. All these animals are brown in the summer but turn white in the winter. Since the tundra is completely covered by snow during the winter, the animals must either hibernate, migrate, or develop special ways to get food.

4. Tropical and temperate forests - The most complex forest communities develop where rainfall is abundant and the average temperature is high. The area which best meets these conditions lies along the equator. There are hundreds of species of trees growing here, some of which reach a height of approximately 200 feet and form a canopy over the rest of the forest area. Only a few species of green plants grow on the forest floor, since the sunlight is cut off. Climbing vines, rooted in the soil, climb the trees to a point where they can get sunlight. Orchids are adapted to live in this environment by having roots which grow upward to catch water and nutrients from the air. The majority of animals live in trees. There is much activity at night as the tree frogs, lizards, and various rodents search for food. The food cycle is the same as other biomes. The green plants are the food producers which are eaten by the herbivores. These in turn are eaten by larger carnivores. The temperate forests exist in an area that has a rapid growing season followed by a dormant period. More vegetation is found close to the ground in the temperate forests because the trees in the overstory are not as tall nor is their folage as dense as the overstory trees of the tropical forest.

The beeches, birches, maples, oaks, elms, hickories, and pines are some of the varieties found in temperate deciduous forests. The typical herbivores of such an area are the deer, rabbits, chipmunks, squirrels, gophers, and mice. Natural predators are mink, weasels, mountain lions, wolves, bobcats, and foxes.

5. Mountain area - Mountain climbers have found that life exists at an elevation of 22,000 feet. Up to 17,000 feet, the cover is similar to the other areas. Dwarfed grasses, sage brush, and sedges predominate this area, while insects such as beetles, ants, wasps, moths, and even butterflies are common up to 16,000 feet. They find shelter in the rocks. At 20,000 feet the limit has been reached for flowering plants.

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Farb, Peter. *The Forest.* New York: Time, Inc., 1963.

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Films of Habitats

The Desert - 22 min. color Encyclopedia Britannica Films

Life in the Desert - 11 min. color B & W " " "

Life in the Forest - 11 min. " " " " "

Life in the Grasslands - " " " " " "

Activities

1. Have students locate the most important life zones of the United States and place these on a map along with some forms of life found there.

2. Make a scrapbook of pictures from magazines and newspapers illustrating various environments.
3. Organize imaginary exploring parties for the purpose of taking a trip into all the realms of the world. Each group should decide on which realm it wishes to visit and what the students of that group will have to take with them. Each group will need to gather as much information about the realm they are visiting as time allows. Then return to the class and give a report of the trip as if it had happened.

ADAPTATIONS

Only man can see the interdependence of the various forms of life established through their adaptations.

I. Definition

An adaptation is the facility of a living thing to change to fit the requirements for continued existence in a given environment.

II. Types of Adaptation

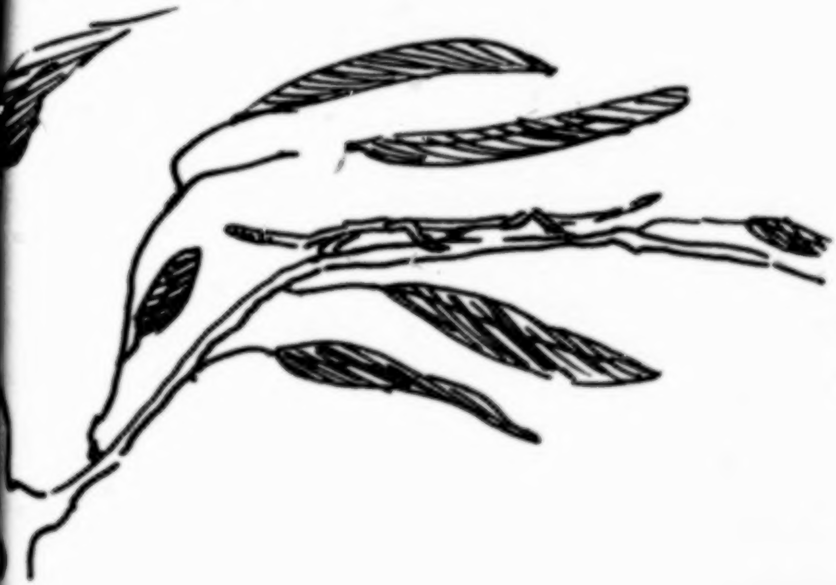
1. Climatic - If living organisms are to survive in any given environment they must adapt to the climatic conditions of the area. Some organisms become adapted to living in hot regions, and others in cold climates. The amount of moisture can also dictate an important climatic adjustment.

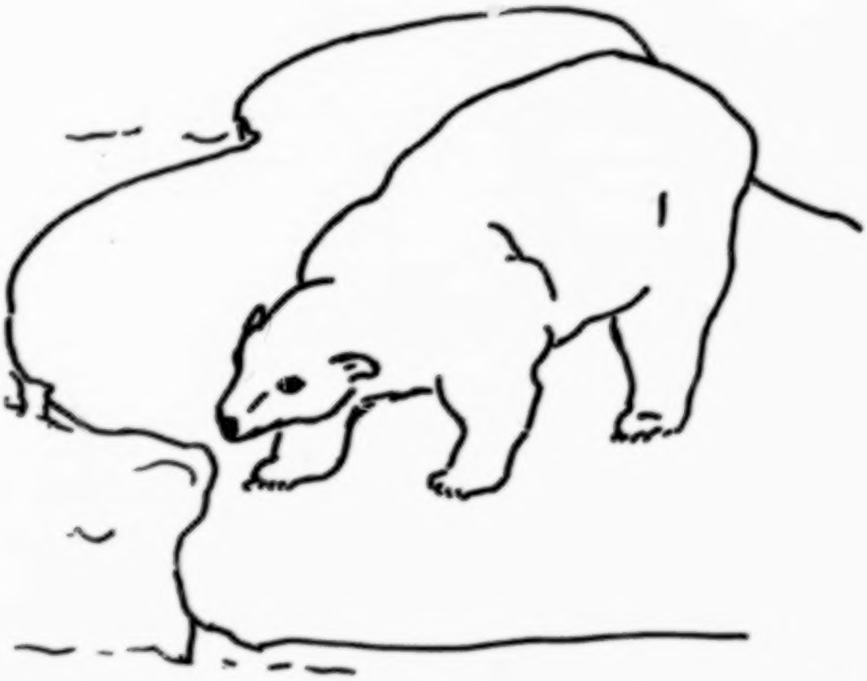
Plants cannot adjust as well as animals to climatic changes. If a horse is taken from a warm climate to a cold one, it can grow a warm coat of shaggy hair. Man can also make adjustments physically, but man is unique in that he can change his surroundings to meet his body requirements. For example, he can wear the type of wearing apparel that will make him most comfortable for the area in which he ventures.

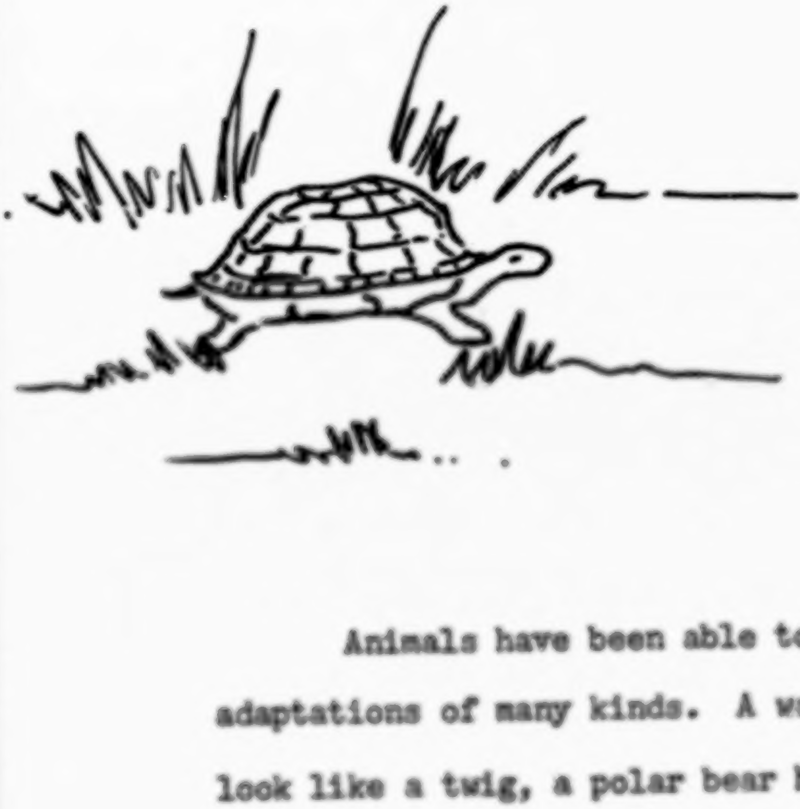
2. Protection - Several animals have protective adaptations which keep them safe from their enemies. These protections vary according to the place where the animals live (environment) and the needs of each species of animal.

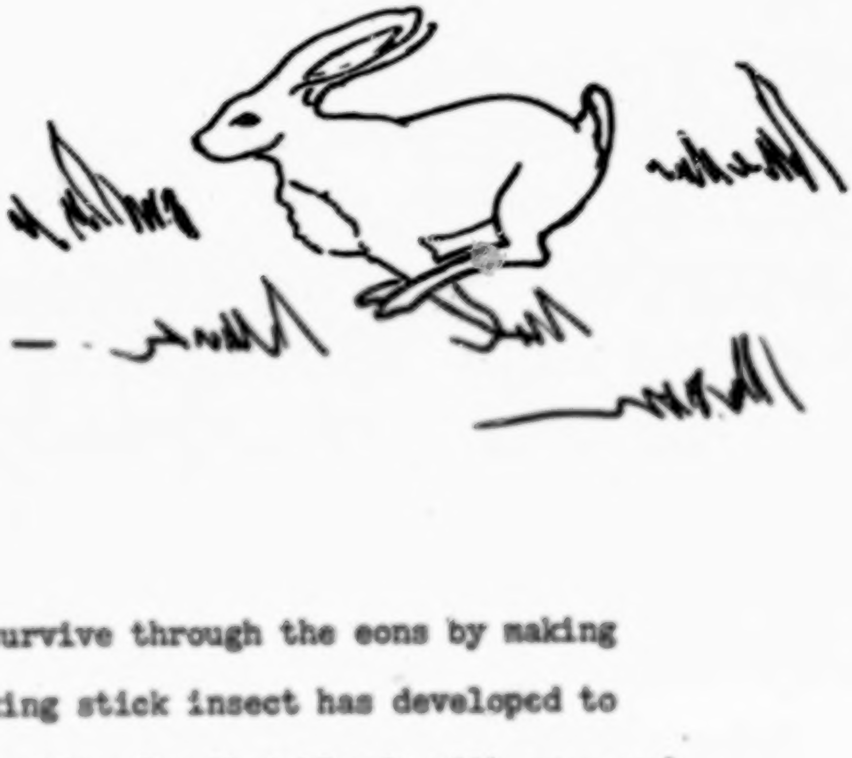
Most animals have some degree of natural color protection from their enemies; that is, their coloration helps them blend in with their natural surroundings.

The arctic fox and the snowshoe rabbit both turn white in winter for protective coloration. Many fish are dark above and light colored below for protection.









Animals have been able to survive through the eons by making adaptations of many kinds. A walking stick insect has developed to look like a twig, a polar bear has white fur that blends with snow and ice, a turtle has a hard shell that protects it. A rabbit projects itself by running fast and rapidly changing direction.

All living creatures tend to develop toward finding ways of eating without being eaten. Some animals show adaptations that protect their soft body tissue. Shells of turtles and various mollusks are examples. The poison of bees and wasps; and the venoms of poisonous snakes and spiders are examples of adaptations that enable a predator to immobilize its victim.

3. Reproduction

   a. The various forms of life have developed many different ways of reproducing themselves, and giving their young a good start in life. The bright colors, sweet perfumes, and nectar of certain flowers are adaptations that attract insects. These insects pollinate the flowers so that seeds will be formed.

   b. Most leaves are adapted for manufacturing food, some, however, serve to store food or play a part in reproduction. Flower petals originated from leaves that adapted for reproductive use.

4. Environment

   a. The surroundings in which a plant or animal lives has much to do with the problems of food, protection, and reproduction to which it must adapt itself.

   b. Every living thing has adapted to some extent to its surroundings--to the sea, fresh water, land, or even to living in other organisms.

   c. Each environment has its own special condition of heat and cold, amount of light and darkness, degree of dryness and wetness, and pressure of air and water. Every animal and plant must live under the special conditions of its particular home.

   d. Each kind of life is suited by its special adaptations, to the physical conditions of the ecological setting where it lives--the kind of soil and nutrients, the amount of moisture and light, and the varying temperature and seasons.

5. Movement - Animals have adaptations of many diverse forms for movement. Burrowing, creeping, crawling, walking, jumping, running, hopping, trotting, galloping, twisting, sliding, sidewinding, swimming,

diving, floating, gliding and flying are each accomplished in a multitude of ways.

Acclimatization

Acclimatization consists of the way in which a plant or an animal adapts itself to a particular climate. Many plants, such as wheat, barley, and the common fruits, grew originally in warmer places than they do today. Man and other migratory forces, have carried these plants into different climates. To live under the new conditions, the plants have had to change either their form or ways of living or both. Certain plants such as the creosote bush, found in dry climates, have acclimatized themselves by sending their roots far underground searching for water. Sometimes the roots go down more than 40 feet.

Human beings can speed up the process of acclimatization by selective breeding of the plants or animals which can best endure the new climate.

A. Changes that take place in adaptation.
    1. Changes in the living conditions of plants and animals are taking place constantly everywhere. Some of the changes are sudden and violent, like earthquakes, forest fires, and outbreaks of disease.
    2. Other changes are so gradual that they can hardly be noticed. Living things must adapt themselves to both kinds of changes. Adaptations to gradual changes are easier to make than adaptations to sudden changes.

B. Extinction
    1. Definition: The complete eradication of a species

2. Causes
    a. Not able to adapt to certain conditions or rapid changes in conditions
        (1) climate
        (2) lack of food
        (3) sinking or rising of ocean shorelines
        (4) rising of the land and elimination of swamp areas
        (5) foolish acts of man
        (6) changes in the underground water table

An extinct animal is an animal that once lived on earth but has died out completely. Many extinct animals and plants including dinosaurs, were prehistoric yet several animal and plant species have become extinct in recent times. Many extinct animals died out gradually as a result of changes in the environment to which they could not adjust. They became fewer in number and finally disappeared when conditions became increasingly bad for them. But some, including the passenger pigeon, were killed off by hunters and displaced by environmental disruptions caused by man.

Sometimes, the earth changed so rapidly that animals did not evolve fast enough to adjust to the changes.

They then became extinct, and were replaced by the migration multiplication, and the development of other kinds of animals. At least two great periods of catastrophic extinction of animals occured on earth. The first was when the Rocky Mountains rose. The second was about 1,000,000 years ago, when the Ice Age began.

Animals sometimes become extinct because of man's foolish waste. Disregard for the principles of conservation will bring about extinction of many birds and animals within this century unless drastic changes are made in human activity.

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Materials

Filmstrips

1. Pre-Historic Life "The Story Fossils Tell"
2. The Living Desert "Survival In The Desert"

Aquarium

ADAPTATION

Experiences

To find how many animals escape their enemies.

Through discussion and reading one may encourage students to become interested in the different ways animals escape their enemies. Research of the literature could be made about animals that are able to avoid close contact with their enemies.

The protective devices of animals could be researched. Illustrations of the protective devices could be made in clay models, in sketches, or in murals. A horse or deer with its long, slender legs could show speed; animals with sharp teeth could show biting; animals with horns and antlers could illustrate how these are used for protection.

Experience: To show the effect of low temperatures on an animal which can survive great variations in temperature.

This may be demonstrated by placing a frog in a container of water to which some ice is gradually added, so that the temperature of the water is slowly lowered. Children can then observe that the frog becomes quite inactive as its body temperature drops nearer to that of the water. After it has stopped all activity, the frog may be taken out of the water and placed where it will be warmed slowly. As its body temperature rises, it will resume normal activity. This demonstration may also be performed by placing insects in a bottle or other glass container and then placing the container in ice water for some time. As the temperature within the bottle drops, the activity of the insects decreases. Grasshoppers or other fairly large insects may be used.

Experience: To learn which animals hibernate in your local community.

Inasmuch as climates differ so widely, this will need to be a local study. Learn what wild animals live in your community and then either ask someone in the community who knows about animals or obtain books to learn whether or not animals hibernate and where.

POPULATION

Definition

The human population of a country is the total number of people who live in it.

Introduction

In certain countries, the rate of increase in population is much greater than the average for the world as a whole. The United States has been an outstanding example. In this country the population was about 4,000,000 at the time that the first census was taken in 1790. It had increased to about 197,000,000 in 1967, or almost fifty times the earlier figure in a little over a century and a half. But this was under exceptionally favorable circumstances; huge expanses of virgin and fertile soil; little serious competition from the comparatively few Indians who dwelt on the land; enormous advances in tools and techniques and discounting the effect of immigration.

The population of the world today is about 3,150,000,000. The distribution of this world population is very uneven. The number of people in the world is increasing at an average rate of about 2% each year.

Causes of Population Growth

1. Great advances in science made in modern times.
2. Improved agricultural methods and stock-breeding have greatly increased the world's supply of food.
3. Great strides have been made in medical science, in sanitary facilities, and in saving lives, especially those of babies.

How the Human Race Meets Its Population Problems

Up to now the human race has been able to meet its population problem more or less successfully by spreading over the earth's surface. Even today there are wide underpopulated areas: Australia, New Zealand, large parts of Canada, Central and South America.

Solving the Problem of Overpopulation by Means of Conquest

The most effective type of population movement at the present time is immigration. Under immigration, the citizens of one state are permitted or invited to move into the territory of another; they generally act on their own initiative and they use their own resources. After World War II considerable numbers of displaced persons joined the ranks of immigrants.

Immigration is not necessarily an ideal solution of the over-population problem. There are certain areas in the world that are sparsely populated because present living conditions are unfavorable. There are immense desert tracts, like the Sahara and the Gobi; and also dense jungles like those of the Congo. If we could succeed in making these regions habitable, they would provide living space for billions of immigrants.

Ways For Improvement

1. Man has succeeded through irrigation in making the desert bloom in Arizona; he has converted the Panama Canal Zone from a "pest hole" into one of the more healthful areas in the world. Reverse osmosis for desalting water and salt water irrigation of highly porous soils looks very promising for developing large arid areas near oceans around the world.
2. The best varieties of crops must be selected and developed for each particular kind of soil.

3. The correct fertilizers need to be supplied to restore fertility to depleted soils.
4. Adequate "cover" vegetation must be established to prevent excessive loss of topsoil.
5. A better use of scientific knowledge in nutrition and animal husbandry should be promoted by ever more efficient world wide distribution of research findings pertaining to these fields.
6. Plant and animal resources from the sea will be brought into vastly greater use.

References

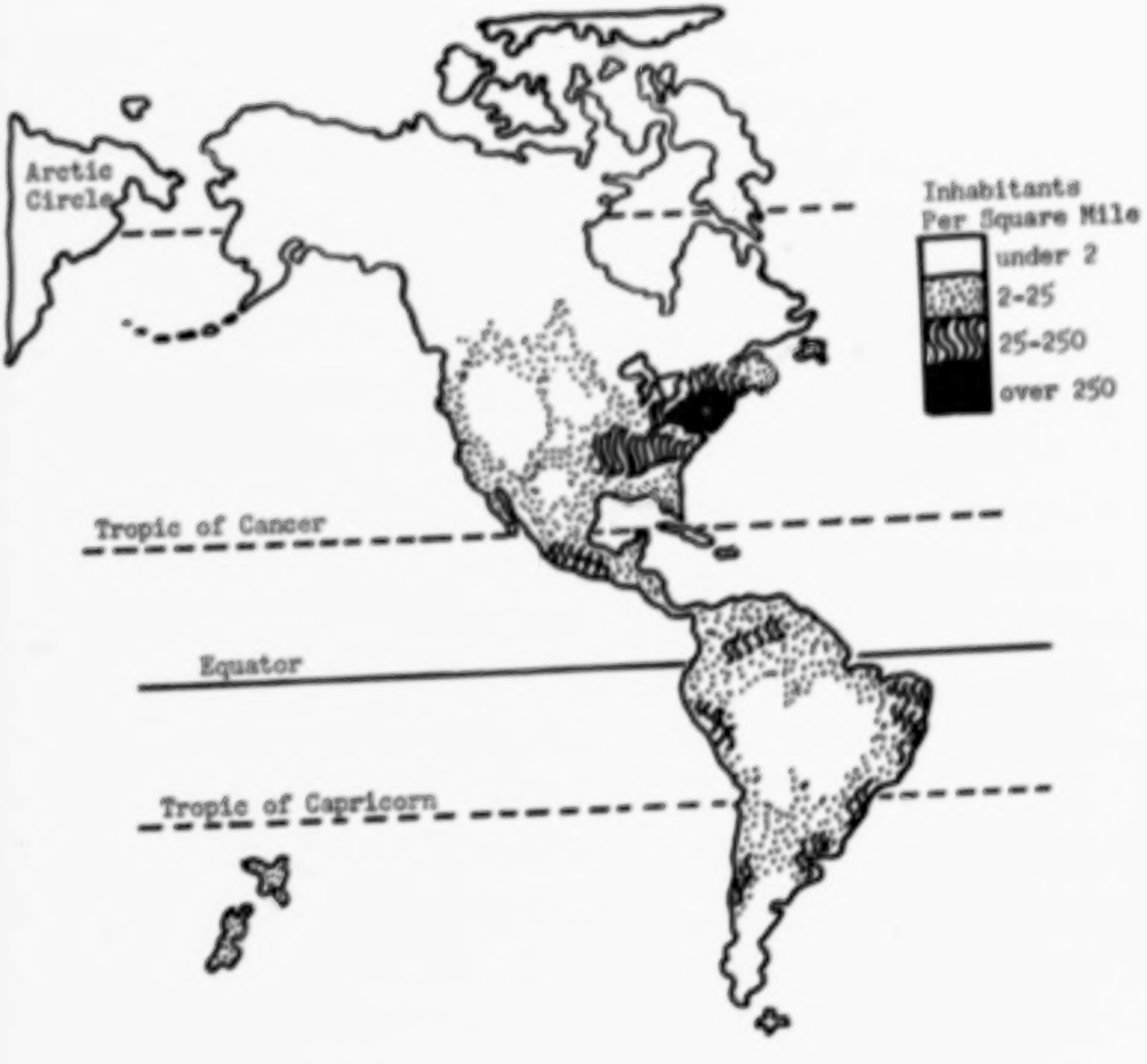
The Book of Popular Science, Volume 3, page 230 (Distribution of the World's Population).

Motion film

"The Population Explosion"--6737.

Learning Resource Guide, University of Texas

DISTRIBUTION OF THE WORLD'S POPULATION
IN NORTH AND SOUTH AMERICA


Arctic Circle
Inhabitants Per Square Mile
under 2
2-25
25-250
over 250
Tropic of Cancer
Equator
Tropic of Capricorn

FIRES

Next to soil and water the forest is man's most valuable natural resource. From the forest comes wood for houses, furniture, fuel, railroad ties, telephone poles, and countless other products. The paper for books, magazines, and newspapers is made of wood pulp. Turpentine, tar, rosin, tannin, fruits, nuts, dyes, and crude drugs are among the forest's many gifts. All of these products and thousands more are very valuable to man.

The forest has many enemies. One of the worst is fire. Nine out of ten forest fires are caused by human carelessness. Seventy-four percent of the forest fires in the United States are caused directly by man. Neglected campfires, cigarettes flipped out of passing automobiles, burning debris from logging operations, and brush fires escaping control are some of the chief causes of fires which destroy millions of acres of forests every year. Quite a few forest fires are caused by lightning.

The most terrifying forest fire is the crown fire that sweeps across the leafy tops of trees. Such a fire takes a high toll in human and animal life. Slow-burning ground fires are less spectacular, but they too are destructive. Seedlings may be killed in ground fires while ground cover and humus are also destroyed. New growth is retarded in such an area because of the absence of viable seeds and too great a concentration of soil salts. Big trees are injured, exposing their wood to insects and fungus diseases. The exposed topsoil of fire-denuded land can be more readily lost through erosion.

Over the years the average acreage burned per fire has steadily declined due to scientific advances in detection and suppression techniques and equipment. The loss from forest fires is still very great. On all Federal, state, and private forest lands during 1964 a total of 116,358 fires were reported; a sizable decrease from 164,183 fires reported during 1963. Acreage burned on all lands was down from 7,120,768 acres in 1963 to 4,197,309 acres in 1964.

In most of the forest states, programs have been started to help prevent forest fires. "Keep American Green" campaigns teach people the importance of preventing fires.

With all the destructions known to be associated with uncontrolled fire it has been a natural force promoting change for eons of time. Interesting research is being conducted at the Tall Timbers Research Station in Florida at the present time. Preliminary findings, in pine forests, surprisingly favor controlled fire at two to three year intervals. This moderate controlled burning is used to eliminate underbrush tinder, which, if left, would support a complete forest burnoff later. Wouldn't you like to know more about fire and the effects of fire--both good and bad? How can you find additional information about the effective use of fire and its control?

EROSION

Definition

Erosion is the wearing away of earth (or rock and soil).

Causes of Erosion

1. Rivers
2. Wind
3. Ocean waves
4. Ground water
5. Ice
6. Temperature
7. Rain

Rivers

Among the forces that leave their mark on the continents, running water, streams, and rivers are thought to do more to change the shape of the land than all other forces combined. A young, vigorous river such as the Colorado River carries away some 500,000 tons of earth, rock, and sand each day. This leaves spectacular formations in the earth's crust, such as the Grand Canyon.

Unhurried but irresistible, the shifting currents of water gradually wear away the surface of the land, producing the familiar forms of hills and valleys, and eventually leaving a landscape flat.

As the jagged contours of the highlands are worn away, rivers enter a less urgent maturity. Their once-steep valleys become broad and flat, and the rivers flow at leisure along winding paths. But even an aging river can be a formidable agent of erosion: during the spring floods the Mississippi daily sweeps some 10 million tons of earth from North America southward to the Gulf of Mexico.

Wind

Wind has changed the surface of the earth through a process called erosion. Wind can move large amounts of soil and sand if the ground is bare, and the particles of sand carried by the wind can cut away solid rock. Wind erosion usually occurs over long periods of time. It, too, is known to be one of the most formidable agents of change of land surface.

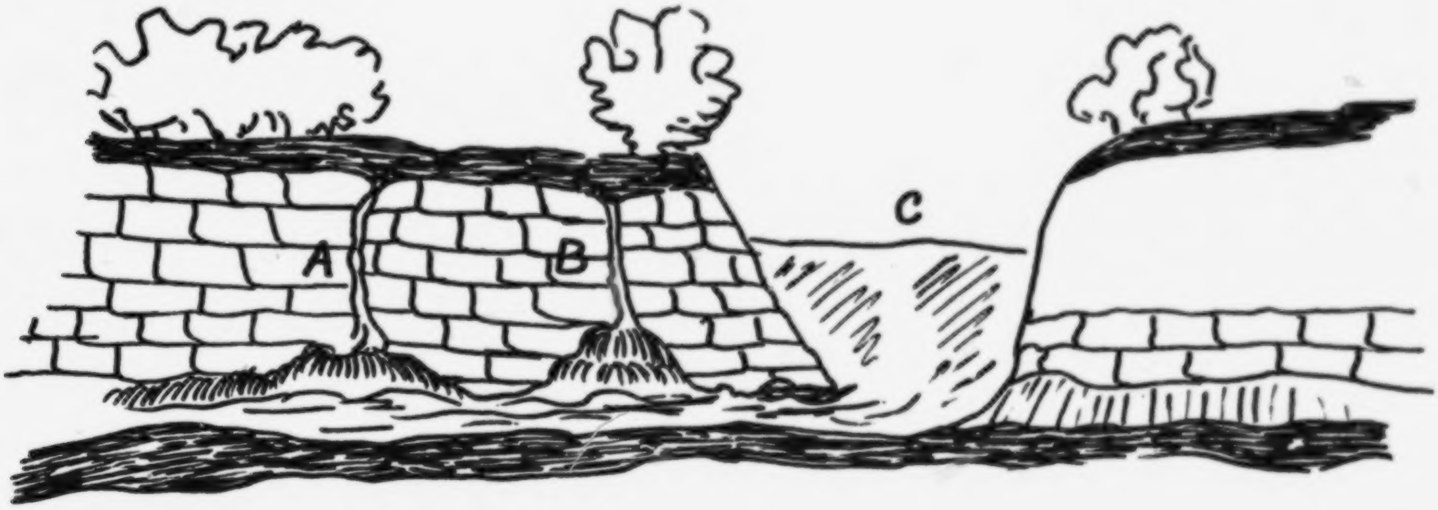
Wind blowing over bare soil may also pile the sand in hills called dunes. Where there are large amounts of sand and the winds blow steadily from one direction, dunes up to 300 feet in height may be formed. If the direction of the wind changes, the dunes may move from place to place covering everything in their path. Trees and fertile land can be ruined by shifting sand dunes. One known way to control dune formation is by planting grasses and other cover crops to keep the soil and sand from blowing. Experimentation is taking place now using petroleum products to stabilize sand dunes thereby promoting the growth of vegetative cover.

Ocean Waves

Waves are produced by wind blowing in gusts over the surface of water. The waves are driven forward by the wind until they reach shallow water where they break, forming the familiar breakers along the shore. Large waves can only be formed where there is a large body of water for strong winds to blow over. The height of the wave determines where it will break.

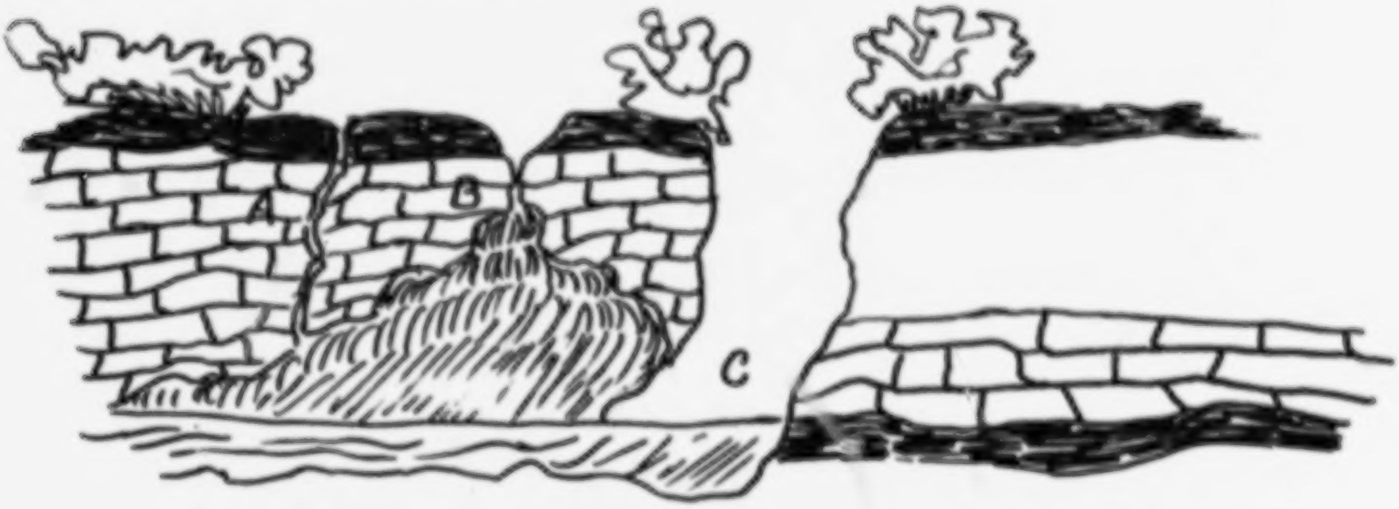
Waves wear away the shoreline by grinding sand and pebbles and even larger rocks against the land. Waves dash against the shores and gradually carve out the cliffs at water level. In some places, this eroding action may be as much as several feet a year. As the base of the cliff is carved away, pieces of rock fall from the upper parts into water. Gradually, over thousands of years, these pieces are broken up and ground against each other to form a beach. As the beach becomes wider and the water becomes shallower, the force of the waves becomes less. Finally, a point is reached where the waves no longer pound against the cliffs. This is seen in the many ocean beaches along our sea shores.

Groundwater



The sketch above illustrates how caves are cut in layers of limestone. Water containing carbonic acid seeps down through fissures in the ground (A and B) and, stopped by a layer of more resistant rock, eats its way laterally through the limestone until it reaches the river level.

In the next sketch, chemical weathering of the cave has continued until fissure B has become a sinkhole and the acidic water has managed to penetrate cracks in an underlying layer of shale. Meanwhile, erosion has deepened the river and lowered its water level, leaving the original cave dry except for seepage.

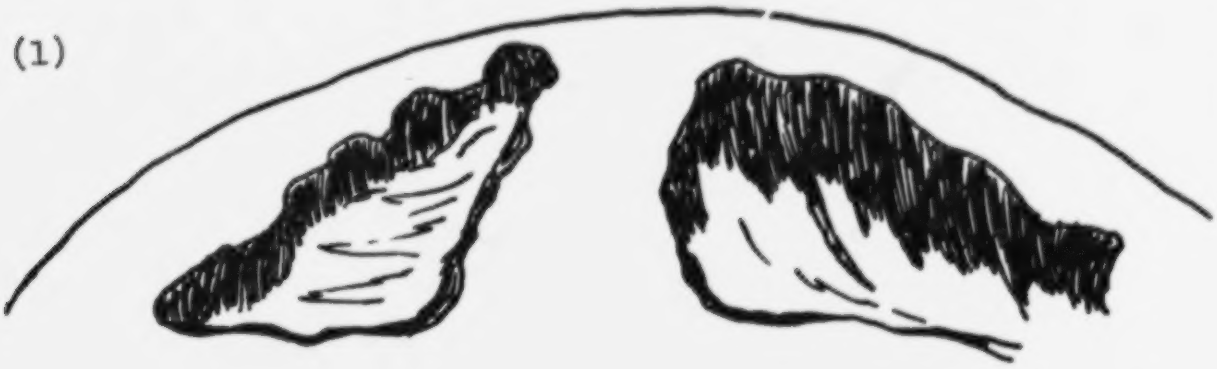


Ice

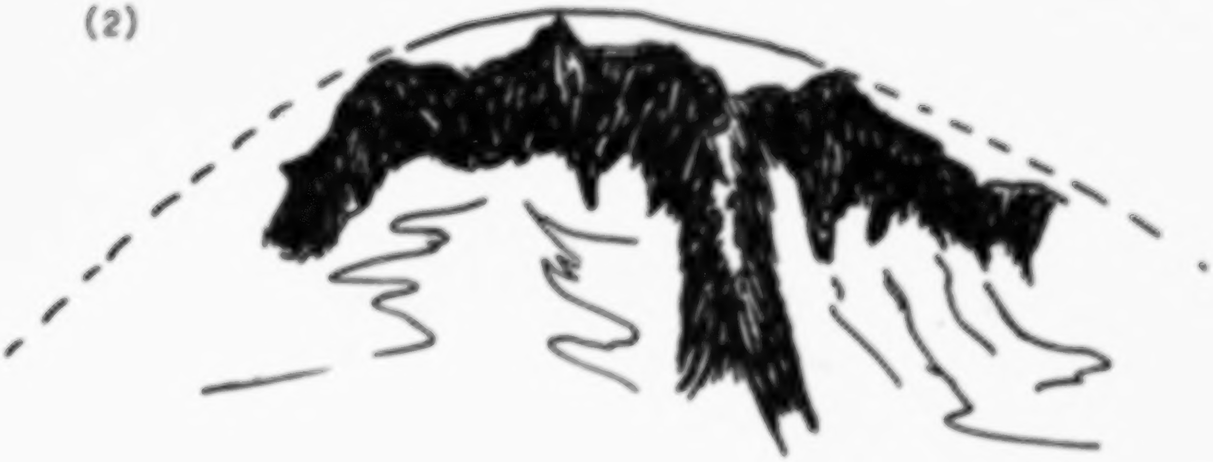
A matterhorn, or sharp peak, gets its shape from the erosive action of glaciers. Snow on a high, rounded summit (1) begins this process by seeping into bedrock as it melts in the sun, and wedging rock chips loose as it freezes at night. When the deepening show hardens into glacial ice, it sweeps the fragments downhill, grinding out furrowed hollows.

The newborn glaciers widen these hollows, as indicated in the center drawing, creating between them crested divisions called aretes. The ice, moving downhill on all sides, keeps undercutting the flanks, leaving a sharp, jagged peak in place of the original dome, shown by a dotted line (3).

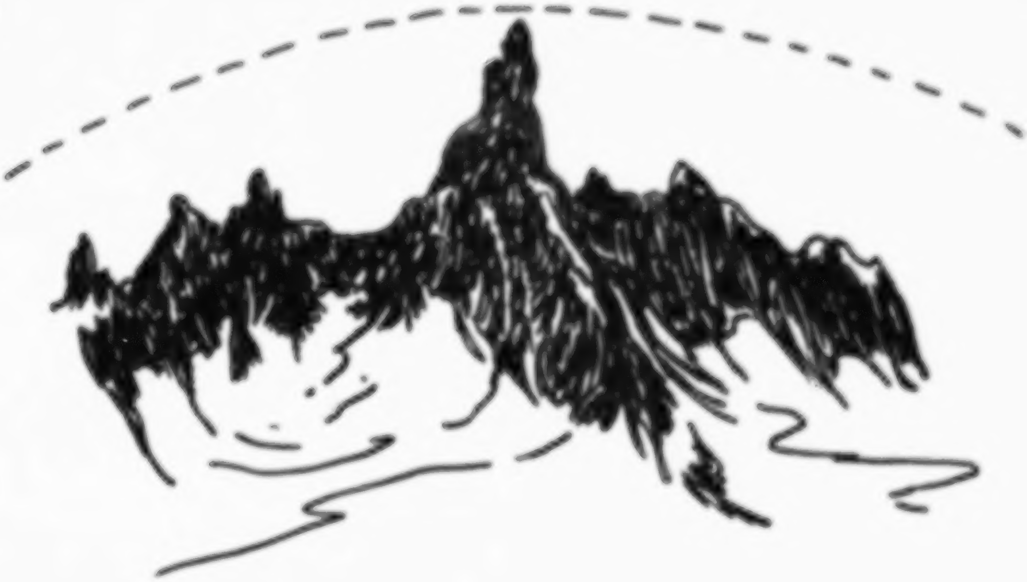
(1)



(2)



(3)



Temperature

Temperature changes also cause weathering of rocks. When heated by the sun, rocks expand. Unequal expansion may cause fractures. Eventually small chunks break off at the rock's edges. A rapid cooling, such as that caused by a cold rain, may also cause a warmed rock to break.

The continual expansion and contraction of rocks over the years break up large rocks into smaller pieces. The smaller pieces are gradually broken down into still smaller pieces until fine particles of sand are formed. This material, mixed with other substances, forms soil, the part of the crust which contains organic materials necessary for plant growth.

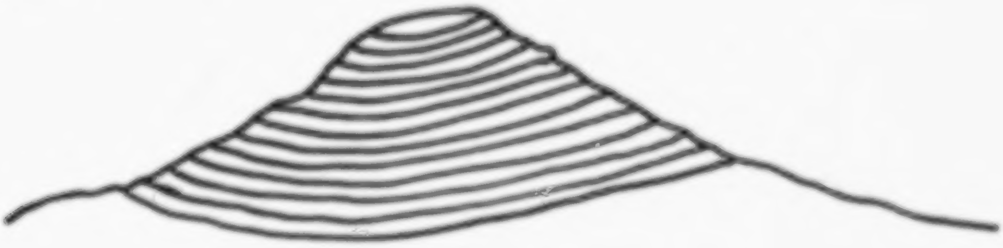
Rainfall

Rain is one of the major causes of erosion. Sheet erosion is caused by rains that wash away the uppermost layer of fertile topsoil. Rain can also wash subsoil from hillsides and form deep gullies. A process called leachout is also caused by long and heavy rainfall. In leaching, rain water seeps through the soil and carries dissolved minerals to levels below the roots of most plants. Rain, through erosion, has ruined thousands of acres of farm land.

Ways to Prevent Erosion

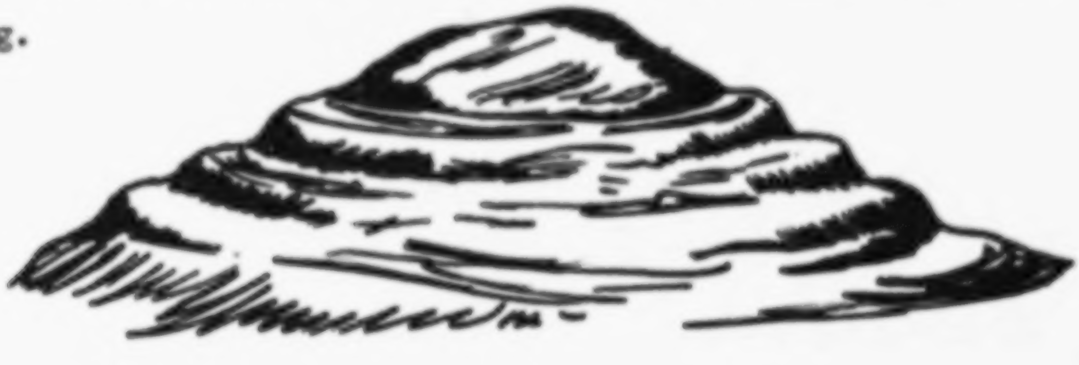
Contour Plowing

This is a method of plowing hills used by farmers to prevent the loss of fertile topsoil. Farmers plow furrows around a slope, rather than up and down. The furrows tend to catch rainwater and keep it from washing away the soil.



Stairstep Terraces

This process is also used on hillsides. The farmer will form terraces like stairsteps on hillsides to prevent an unchecked flow of water down the hillside. Terraces hold the water and provide more level land for farming.



Forest

Some valuable land is saved from erosion by planting trees. Sometimes trees are planted on hillsides and in low places to prevent erosion by water. The roots of trees hold the soil in place and keep the fertile topsoil in place. Trees can be valuable in flat lands, too. The humus that builds up under trees enriches the soil and acts as a sponge to more slowly let rainwater seep through it. Streams in heavily wooded areas tend to be clearer and more regular in flow than comparable denuded areas.

Grasses

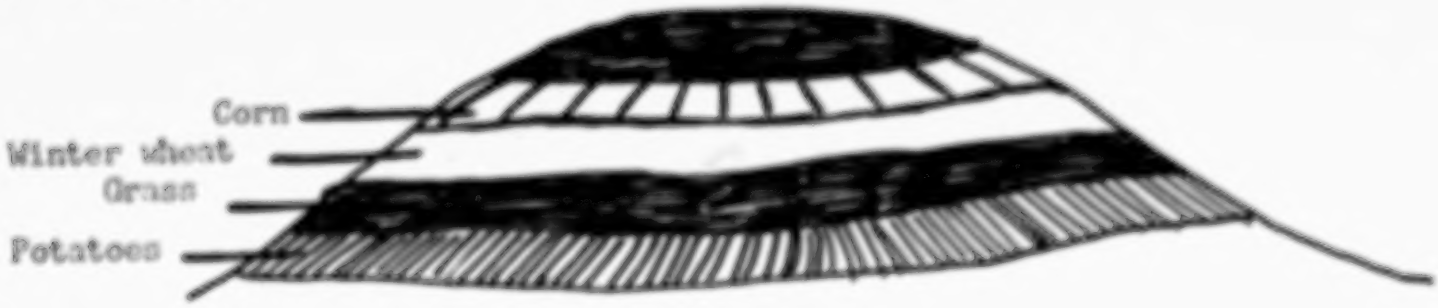
Grasses are used in much the same way as trees. Their roots also prevent the erosion of soil by holding it in place.

Dams

Gullies are usually formed when water flows down a hillside unchecked. Dams can be built across gullies to slow down the silt-laden water in its rush to lower levels. When the water slows down it loses silt and doesn't have as much velocity to wash out soil farther down the slope. Dams can be used to deter the gullying process, to refill the area behind the dam, to protect the area ahead of the dam, and to raise the water table in the immediate area. Used with reforestation and sod building dams can perform useful and lasting functions in controlling soil erosion.

Strip Cropping

This procedure lends itself to use with contour plowing. Farmers raise different crops in contoured strips along the slopes. If a gully starts in one strip, the plants in the next strip stop it before it becomes very big. Soil may wash down the slope a short way, but it is soon stopped.



Bracing

This is a process used in construction. This process is to stop erosion before it starts by creating a dam-like barrier against a steep slope of denuded soil.

EXPERIENCES

How Plant Cover Affects Soil Loss

Purpose

To show how plant cover reduces soil loss.

Equipment and Material

2 boards 1 inch thick

2 watertight boxes (approximately 16 inches long, 12 inches wide and 4 inches deep). These boxes may be used for several demonstrations. Cut a "V" notch 1 to 1½ inches deep at one end of the boxes and fit a tin spout in the notch.

2 one quart or larger sprinklers (flower sprinklers or jars with holes punched in lids.

1 piece of sod cut (from pasture or lawn) to fit one of the boxes.

1 soil sample (no grass or cover, but not necessarily a poor soil).

2 half gallon fruit jars or equal sized pans.

Procedure

Fill one box with the sod sample. Trim the grass so that it is not more than 1 inch high. Place the soil sample without cover in the other box. Place the end of the box with a "V" notch so that the spout will throw "runoff" water into the containers. Set the boxes on a table so that the spouts are over the edge. Put the empty fruit jars just beneath the spouts. Place a board 1 inch thick under the end of each box opposite the spout. Take the two sprinklers filled with water and pour steadily at the same rate and same height (about one foot) from both boxes.

Results

Water from the bare soil will run rapidly down the box, over the spout and into the fruit jar taking large amounts of soil with it. The water poured onto the sod will take longer to start flowing. However, it will be reasonably clear, less water will reach the fruit jar, and the flow of water will continue for a longer time than with the bare soil sample.

Conclusion

The sod breaks the force of the raindrops, the humus and roots soak up and retain much moisture, and the roots hold the soil in place. Therefore, the soil is not broken apart and washed out of the box. The plant cover also tends to slow down the rate of water so that it does not have enough speed to disrupt the soil.

Note: The amount of water in the sample of sod and soil will affect this demonstration some, but unless the soils are waterlogged, the demonstration should be successful.

What Contouring Does

Purpose

To show that by contouring our land we can decrease soil and water runoff.

Equipment and Materials

2 boxes (approximately 16 inches long, 12 inches wide, and 4 inches deep). These boxes may be used for several demonstrations. Cut a "V" notch 1 to 1½ inches deep at one end of the boxes and fit a tin spout into the notch.

2 soil samples

2 sprinklers

2 boards 1 inch thick

2 wide-mouth fruit jars (approximately ½ gallon)

Procedure

Make furrows across the soil in one box and down the soil in the other, using your finger or a pencil. Place one widemouthed fruit jar under each spout. Place the 1 inch board under each box opposite the spout. Taking a sprinkler filled with water, pour steadily at the same rate and height on the boxes of soil.

Results

The water sprinkled over the box of soil with furrows running "up and down hill" will run down the furrows at a great enough speed that it will pick up soil and carry it up the spout and into the fruit jar. The water sprinkled over the box of soil with contours running perpendicular to the slope will be slowed down, held in the furrows and will give the water more time to soak into the soil. This will result in the water flowing less rapidly; therefore, there will be less soil movement and less water runoff.

Conclusion

Running your rows up and down the slope gives water falling on the land a chance to pick up enough speed to remove considerable soil with it. Running your rows on the contour, that is, perpendicular to the slope, tends to reduce the speed of the water and reduces soil runoff. By reducing the speed of the water and keeping it on land longer, you get the added advantages of giving the water more time to soak in the land. More water is held and it is held longer. This is why contour farming is recommended on sloping land as a conservation practice. Contour farming alone will not stop erosion; therefore, for best results, you should use it with a combination of other conservation practices.

Just as the increase in man's numbers coupled with shortsighted quick-profit seeking actions have contributed to increasing soil erosion, these same factors are contributing to the destruction of the vital features of many ecosystems. The resulting changes have caused the extinction of many plants and animals, and if unchecked, will soon lead to the extinction of literally hundreds of other species.

Wanton killing removed the dodo bird from the list of living species and contributed, along with the destruction of nesting areas, to the extinction of the passenger pigeon.

The influx of man has contributed to the extinction of many birds including the Ivory-billed Piliated woodpecker which was the largest of its kind. Extensive cultivation, and expanding towns and cities continue to further restrict the habitats of our animals and plants. Roadside weed spraying programs in many states have virtually destroyed the last vestiges of original broad leaf flora. The draining of swamplands surrounding refuge areas in Florida in 1967 combined with a drought has damaged the natural refuge of rare birds, animals, and plants to the point that extinction is almost a certainty for many species there. The destruction of salt water marshes along our seacoasts threatens vast quantities of sea life. The green turtle is threatened with extermination and the great sperm whale, the largest living thing of all time, may already be reduced too low in population to be able to recover. Our stewardship must improve at breakneck speed if future generations are to have use of hundreds of species lingering on the brink of complete eradication.

POLLUTION

Objective

To help the student realize the rapidly increasing rate of pollution and to understand the influences of pollution and its effect on their future.

References

Local - See your city and county committees of industrial control and zoning. Consult annual reports (in larger cities in particular) on pollution.

State - Contact State Game and Fish Commissions and Forestry Commissions.

National - Atomic Energy Commission
Refer to the Bibliography for "Wildlife", in chapter X. These sources will send information about man's wasteful use of nature through pollution.

Suggested Activities

Make clipping notebooks showing current publications involving pollution.

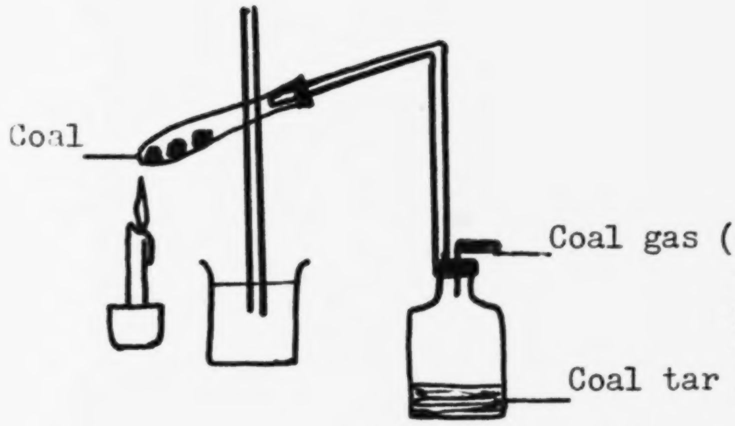
Suggested Individual Research

1. Longevity and its relation to environment of man.
2. Fishing or hunting prospects in your neighborhood in comparison to the same prospects 50 years ago. Consult newspaper records or elder members of the community who knew area before industrialization.
3. Ask selected students to find and report to the class information on how the disposal of atomic wastes produces problems for the present and the possible implications of these problems for the future.

Experiments

Destructive Distillation of Coal

This experiment effectively produces the more obvious effects of pollution; the odor of coal gas and sticky tar.



(will burn with a sustained flame if apparatus is fitted to terminate with the glass of a medicine dropper.)

Destructive Distillation of a Cigarette

Use the same equipment as destruction of coal. Using two ordinary cigarettes.

Pollution may mean either "natural" or "industrial" contamination of the basic environments of earth's creatures.

The major areas where pollution is a problem include:

1. Rivers, streams, fresh water lakes
2. Oceanic waters
3. Air
4. Soil

The sources of pollution include:

1. Improper disposal of human wastes
2. Inconsiderate dumping of wastes by industry
3. Combustion products of both industrial and citizen sources, such as:
    a. Automobile exhaust fumes
    b. Burning of trash
    c. Industrial exhaust fumes

The injurious effects of pollution to mankind:

1. Depletion of safe-drinking water sources
2. Increases in respiratory diseases because of polluted air

3. Transportation hazards created by decreased visability.

4. Rapid deterioration of buildings, fabrics, and other erodible constructions of man.

5. Depletion of food sources due to injurious effects on many members of the broad web of life represented in the biosphere.

The effect on weather:

Increasing amounts of carbon in the form of carbon dioxide is being released into the atmosphere. This is causing a worldwide temperature increase which may influence melting of northern and southern polar ice caps causing a rise in oceanic water levels. The oceanic water level increase may lead to the oceans claiming lowlands unless large dike systems are built.

Correction of pollution problems may include:

1. Internation supervision of air and oceanic waste disposal.
2. National prevention of pollution via industrial control and enforced laws.
3. Individual discipline to cooperate in solving the pollution problem.

Experiences

How do cities dispose of their sewage?

Find out what type of sewage-disposal system is used on a farm, in a city, or in local areas. It may be possible to take the students to visit a city sewage disposal system. Visit the bank of a stream below a city that has an effective sewage disposal system. Compare this stream condition with the condition of a stream below a city that does not have an adequate sewage treatment plant.

Man sees the value of such things as:

I. Carbon
    A. Description - One of the substances in food made by green plants.
    B. Chemical symbol - C

C. Sources

1. Rocks containing carbonates
2. Air
3. Water

D. Uses

1. Fuel
2. Fire extinguishers
3. Source of energy
4. Synthetics
5. Medicine
    a. Antibiotics
    b. Aspirins
    c. Penicillin
6. Raw materials for food
7. Diamonds

E. Quantity

1. 500,000 carbon compounds have been identified.
2. 300 million tons made into food materials by green plants each year.
3. 10 billion tons of carbon released by industry. That amount will double in a century.

F. Cycle

1. Illustrate with films, transparencies and drawings.
2. Build living aquarium systems.
3. Take field trips to show decaying plants.
4. Start a fire with water by sugar and sodium peroxide to show the requirements of fire and the results of combining carbon and oxygen. (50-50 mixture of sugar and peroxide)

II. Nitrogen

A. Description - An essential element of protoplasm, and a distinguishing component of proteins.

B. Symbol - N

C. Quantity - 78% of atmosphere is nitrogen. Found in every living thing.

D. Uses - In every living cell for growth and metabolic process.

E. Cycle

1. When plants and animals die, when leaves fall from trees, or

when an animal excretes its waste, the nitrogen compounds present in all these substances pass into the soil or water.

2. Certain bacteria in the soil or in the water begin to break down these organic nitrogen compounds. One of the end-products is ammonia.
3. Chemical reactions occur in which ammonia gas is changed to an ammonium compound, a soluble salt. The salt ionizes to produce ammonium ions which some green plants can take directly into their roots.
4. Nitrifying bacteria in the soil oxidize ammonium ions to water and nitrites. Others oxidize nitrites to nitrates.
5. The highly soluble nitrates, dissolved in the soil water, are taken up by the roots of plants.

III. Oxygen

A. Description - A life giving gas and chemical element that has no color, odor, or taste.

B. Chemical symbol - O

C. Sources

1. Plants
2. Air

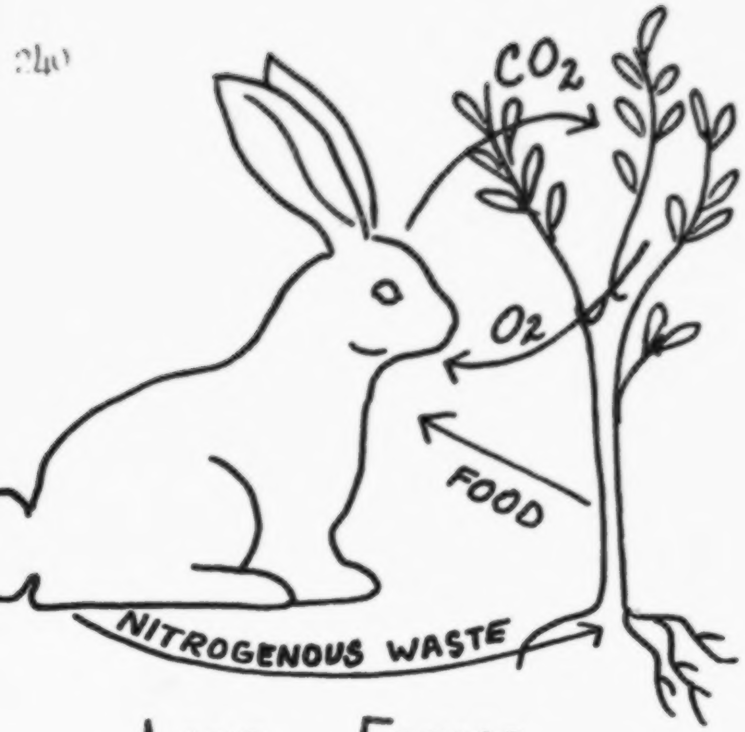
D. Uses

1. Necessary for combustion.
2. Supports many life processes.
3. Combines with many other elements to form a large percentage of rocks and minerals in the earth's crust.
4. Much food we eat combines with oxygen to yield energy as well as heat.

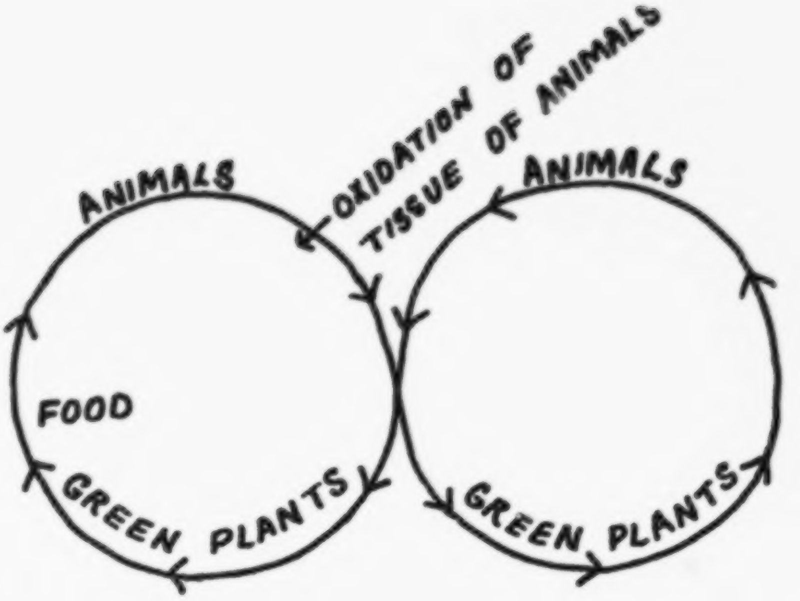
E. Quantity - Twenty percent of the atmosphere is made of oxygen.

F. Cycle

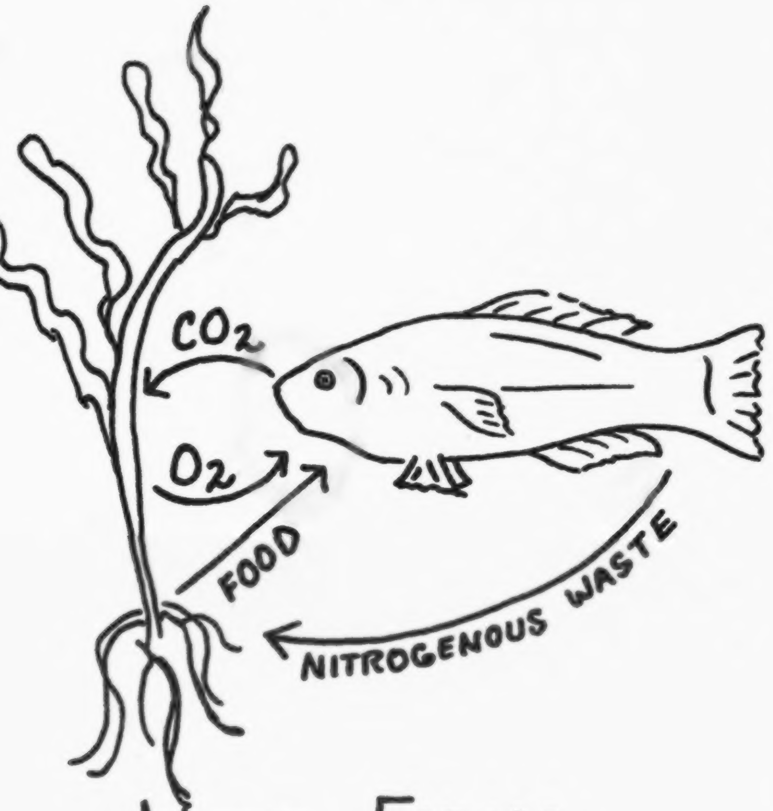
Green plants use chlorophyll, light, water, and carbon dioxide to make foods. An animal eats the food and gains energy. At the same time it takes in carbon. Then the animal digests the food it eats which gives energy to the cells. Waste materials in the form of carbon dioxide and water are released. The animal releases the carbon dioxide into the atmosphere. Thus we have a cycle. Carbon dioxide leaves the atmosphere through photosynthesis and reenters the atmosphere through animal and plant respiration. Photosynthesis and respiration keep the cycle going.


CO2
O2
FOOD
NITROGENOUS WASTE

Land Forms

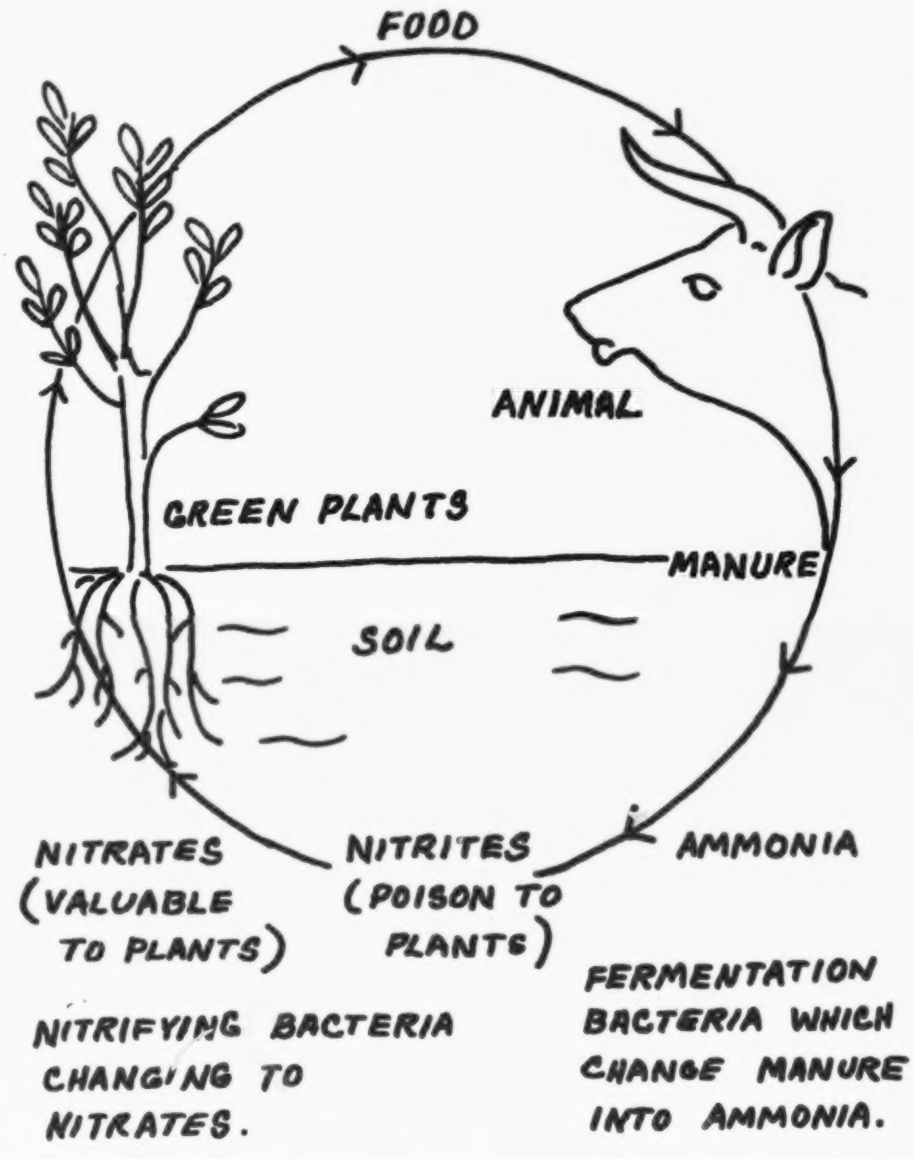

ANIMALS
OXIDATION OF TISSUE OF ANIMALS
ANIMALS
FOOD
GREEN PLANTS
GREEN PLANTS

Oxygen and Carbon Cycles


CO2
O2
FOOD
NITROGENOUS WASTE

Water Forms

Balance Cycles


FOOD
ANIMAL
GREEN PLANTS
MANURE
SOIL
NITRATES (VALUABLE TO PLANTS)
NITRITES (POISON TO PLANTS)
AMMONIA
NITRIFYING BACTERIA CHANGING TO NITRATES.
FERMENTATION BACTERIA WHICH CHANGE MANURE INTO AMMONIA.

Nitrogen Cycle

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CARBON

Experiences

What are ashes?

It may seem strange that ashes are left after coal has been burned, since coal is mostly carbon and forms carbon dioxide when burned. Carbon dioxide is an invisible gas, and certainly does not form ashes. In the main, the ashes are that part of the coal which is not carbon. They represent the part which either does not burn or forms a solid substance when it does burn. A little of the carbon may remain unburned as part of the ashes.

What is smoke?

Some fires make smoke, and others do not. Smoke is made up of millions of tiny particles of ashes which are light enough to float in the air. If the ashes are made up of large pieces, there may be no smoke; but if they are made up of very small pieces, there may be a thick smoke.

Making soot.

When we burn a candle and hold a glass over the flame, the glass becomes covered with soot. Soot is nothing but carbon which has not burned. Soot is often collected on a large scale, and used for making printer's ink, automobile tires, etc.

OXYGEN

Experiences

There is air in water.

Fill a jar or tumbler with cold water. Allow it to stand undisturbed for a few hours. Small bubbles will collect on the side of the jar or tumbler. These bubbles are air which was in the water. Cold water can hold more air than warm water; as water warms, air leaves it. It is this dissolved air that is used by fish in breathing.

To remove the air from water

Put some water in a pan which can be heated. A clear cooking dish may be better if one is available. Heat the water over a hot plate. Watch for the bubbles of air that come out as the water is heated. The bubbles that come out before the water starts boiling are mostly air. The bubbles that rise to the surface after the water is boiling are filled mostly with steam. True steam is water vapor at the temperature of boiling water and it is completely invisible.

Air affects the taste of water.

Put some water in a clean pan or kettle so that it can be heated. Heat it until it has boiled for 20 minutes. Most of the air which is dissolved in the water will be driven out. Set the water aside while it cools. Then, being careful not to stir it, pour samples into cups for the children to taste. They will notice that it tastes different from what it did before it was boiled. Now mix the remaining water with air by stirring it vigorously or by pouring it back and forth from one container to another several times. After it has been mixed thoroughly with air, have them taste it again. The children will notice that putting the air back into water improves the taste.

CARBON DIOXIDE CYCLE

Experience

To show there is carbon dioxide in soda water.

Soda water, such as is sold as bottled "pop" at vending machines, is made with water which contains carbon dioxide. When the pressure of the gas is released, as in removing the cap from a warm, shaken "pop" bottle, the gas escapes and produces bubbles.

To test for carbon dioxide

Pour some fresh limewater into a jar of carbon dioxide and shake vigorously. (To prepare limewater, obtain some lime from the hardware or paint-supply store. Stir a tablespoonful of lime into a pint of water. The water will dissolve some of the lime, but will be milky in appearance. The undissolved lime can be filtered out.) The limewater turns milky; and if it is left undisturbed for a while, a white substance may be seen to settle at the bottom. This milky precipitate shows the presence of CO_2.

To test breath for CO_2

With a paper, a plastic straw, or a piece of rubber tubing, blow breath through some fresh limewater. Is a milky precipitate formed? Does this test indicate the presence of CO_2 in exhaled breath?

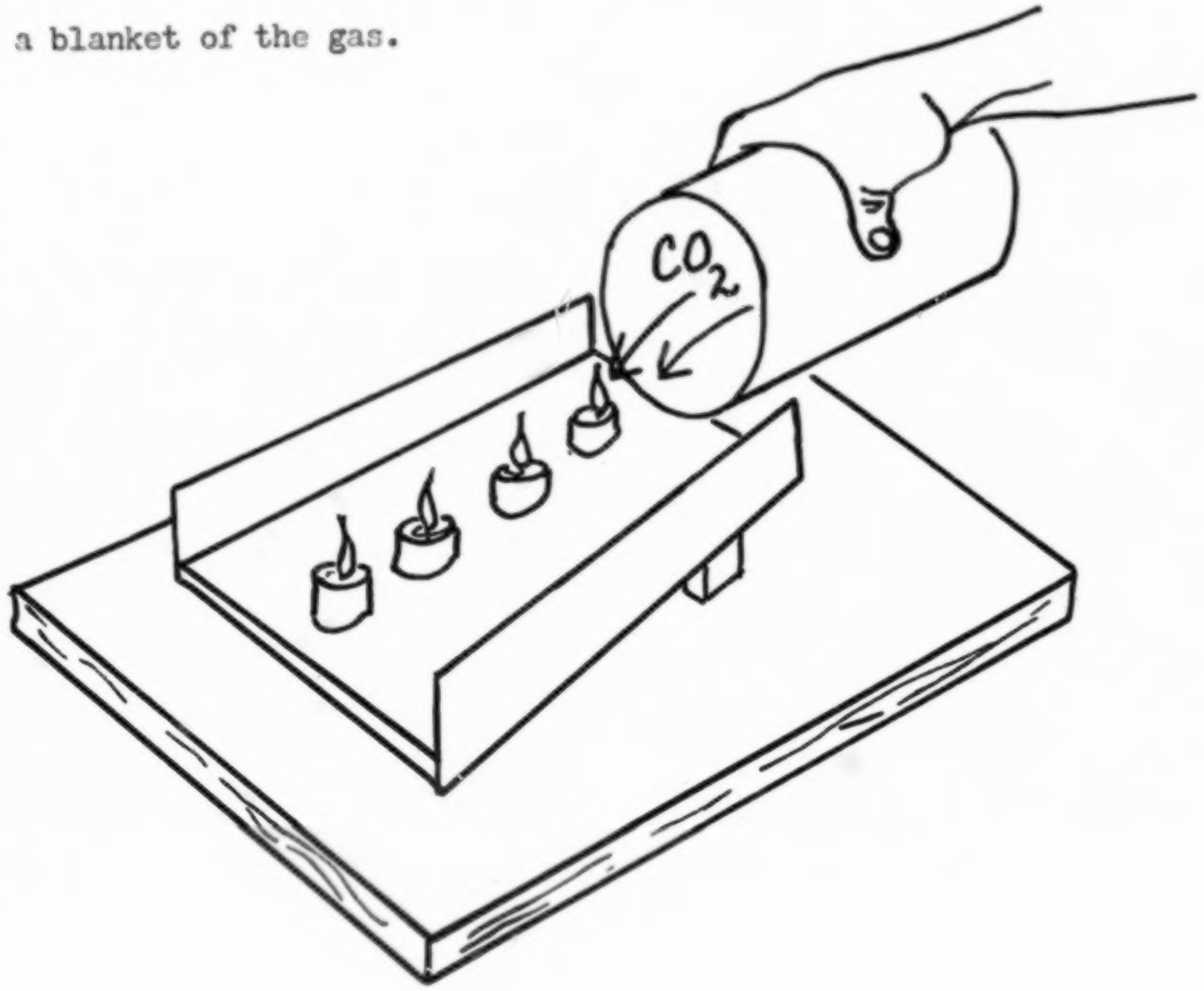
Making and Using CO_2

Place a handful of washing soda in a fairly tall tumbler. Set the tumbler inside a large glass or tin jar. (A large cannister or other large container with wide mouth will do.) Pour into the soda about half a cup of strong vinegar. The soda will bubble vigorously as it gives off CO_2. The glass jar now contains a large supply of CO_2.

Arrange three or four lighted candles on a slanting board with pieces of cardboard tacked to the sides so as to form a trough.

Quickly remove the tumbler from the jar and pour the carbon dioxide (in the jar) down the trough just as you would a jar of water. The candles should be extinguished. Carbon dioxide is much heavier than air and will run downhill, just as water does. CO_2 puts out a fire by shutting off the oxygen from it.

Prepare another jar of CO_2. Fasten a candle to a piece of wire and lower the lighted candle into the jar. As it becomes immersed in CO_2, it goes out instantly. Many commercial fire extinguishers use CO_2 to put out fires. The effect of such extinguishers is to surround the fire with a blanket of the gas.



ECOLOGY

How does man profit from an understanding of checks and balances in nature?

Definitions

Ecology - The branch of biological science that deals with interrelationships between living things and their environments. Ecologists study the effects of the environment on each organism and each organism's effect on the environment.

Balance of Nature - A system by which plants and animals are kept in relative balance with one another in a state of dynamic equilibrium.

Factors Influencing the Balance of Nature

1. Water and food supply
2. Climate and terrain
3. Disease
4. Natural enemies
5. Man
6. Natural disasters
7. Other organisms

Water and Food Supply

Remove or cut off the source of food and water supply of any species and the result will be an imbalance of nature. In other words, the food web is broken. Many relationships exist between plants and animals only because of the need for food. This relationship develops the food web, in which a large organism feeds on a smaller organism. The food web always begins with a green plant since green plants are the original source of food for all living things. Plants get their nutrients from the soil or the air. Animals can be separated into three (3) types according to their feeding habit:

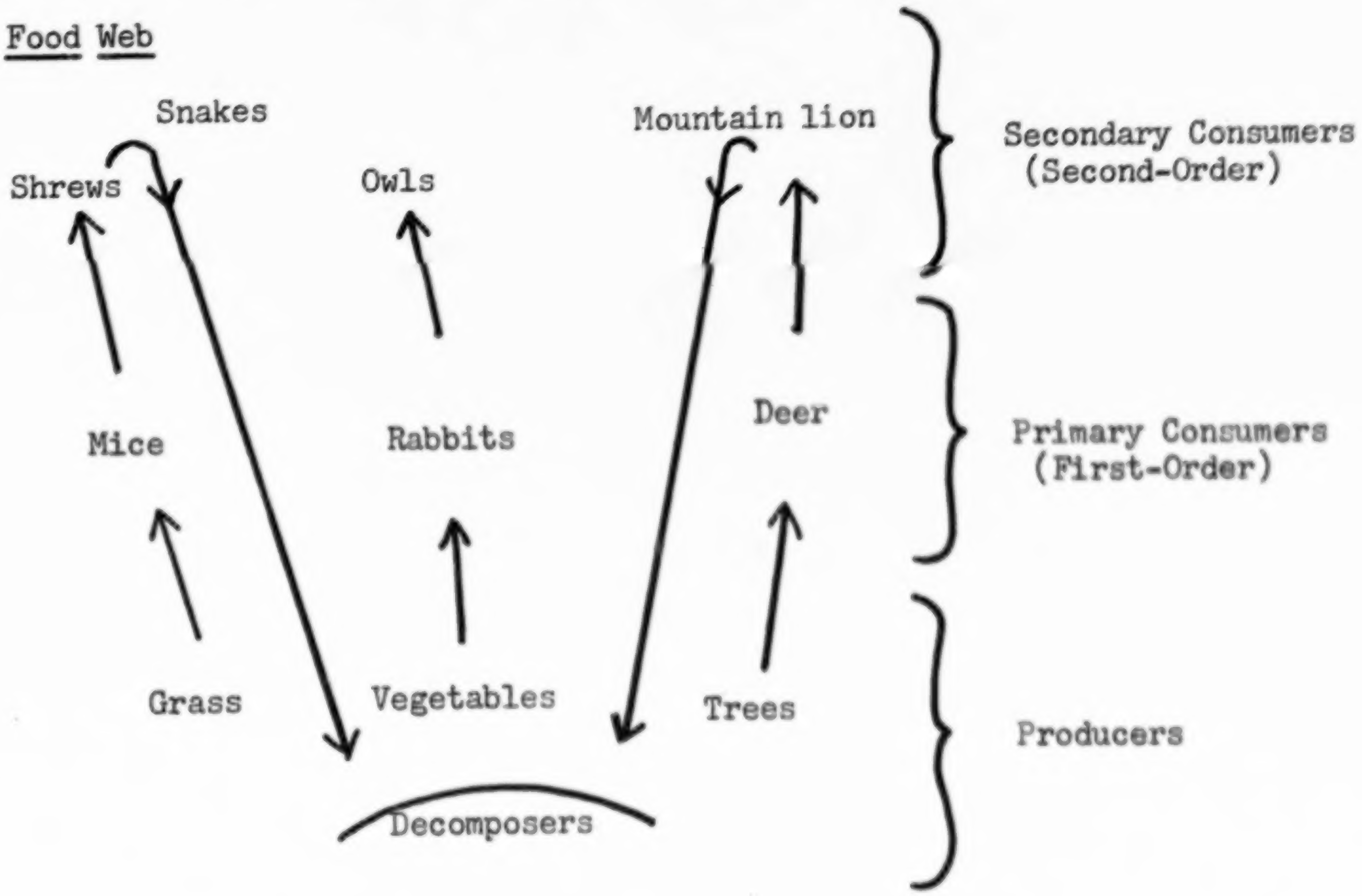
1. Carnivorous - meat eaters
2. Herbivorous - plant eaters
3. Omnivorous - plant and meat eaters

Many organisms depend on other organisms for their food:

1. Saprophytes - organisms capable of obtaining their nutrition from organic compounds. (example - bacteria)
2. Parasite - organisms that grow at the expense of others.
3. Symbionts - organisms that benefit from each other.

In the food web, as a general rule, each succeeding consumer becomes larger but scarcer. Also each further step away from the origin seems to require the corresponding consumer to eat more food according to its size. Food webs constitute another way of looking at the interdependence of living organisms. This too, is a facet of ecology.

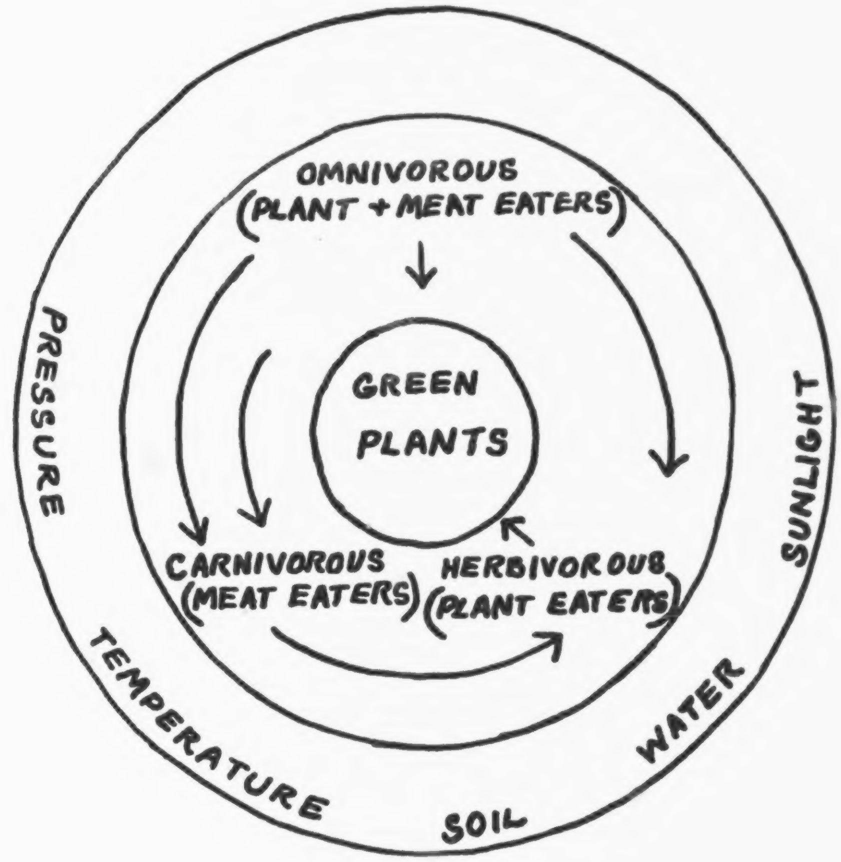
Food Web


Snakes
Shrews
Owls
Mountain lion
Secondary Consumers (Second-Order)
Mice
Rabbits
Deer
Primary Consumers (First-Order)
Grass
Vegetables
Trees
Producers
Decomposers

Consumers live at the expense of producers, and decomposers return the materials of the dead to the reservoirs of the atmosphere, fresh water, seas and soil. The living system is always in balance with what is outside it and around it - its environment.

Interdependence of Plants and Animals

(The green plant provides the original source of energy in the food web.)


OMNIVOROUS
(PLANT + MEAT EATERS)
GREEN
PLANTS
CARNIVOROUS
(MEAT EATERS)
HERBIVOROUS
(PLANT EATERS)
PRESSURE
SUNLIGHT
TEMPERATURE
SOIL
WATER

Climate and Terrain

Through geological time drastic changes as well as gradual changes of the temperature and climate have affected the balance of nature. Severe cold, heat or dryness sometimes has killed off whole species of animals and plants. The erosion and weathering of the land have also affected the balance of nature. In modern times man has entered the picture by utilizing large machines to change the surface of the land, such as filling in of a swamp.

Disease

An imported disease can strike out of existence certain members of an ecosystem. The plight of the American Chestnut is a case in point.

Natural Enemies

Nature has prevented any species of plant and animal from getting too numerous by providing natural enemies. Example - plant lice eat plants; ladybirds (beetles) eat plant lice; birds eat beetles; hawks and snakes eat birds; and so on.

Man

Most of man's activities tend to reduce the number of species of animals and plants in his vicinity. With traps, guns, and poison he eliminates the predators (wolves, bobcats, hawks, owls). Almost at once he is faced with large numbers of other animals for, with the predators gone the primary consumers, such as deer, rabbits, and grasshoppers, multiply without their usual checks. Man becomes a factor introducing stress into the environment.

Natural Disasters

We can see a dramatic bit of the adjustment that takes place when life is wiped out or grossly disturbed somewhere and then gradually returns to normal through a succession of relationships, leading to a climax when the fullest possible balance of nature is restored. As examples, the invasion of a new volcanic island by living things or the renewal of life in an area devastated by fire, offers illustrations of succession.

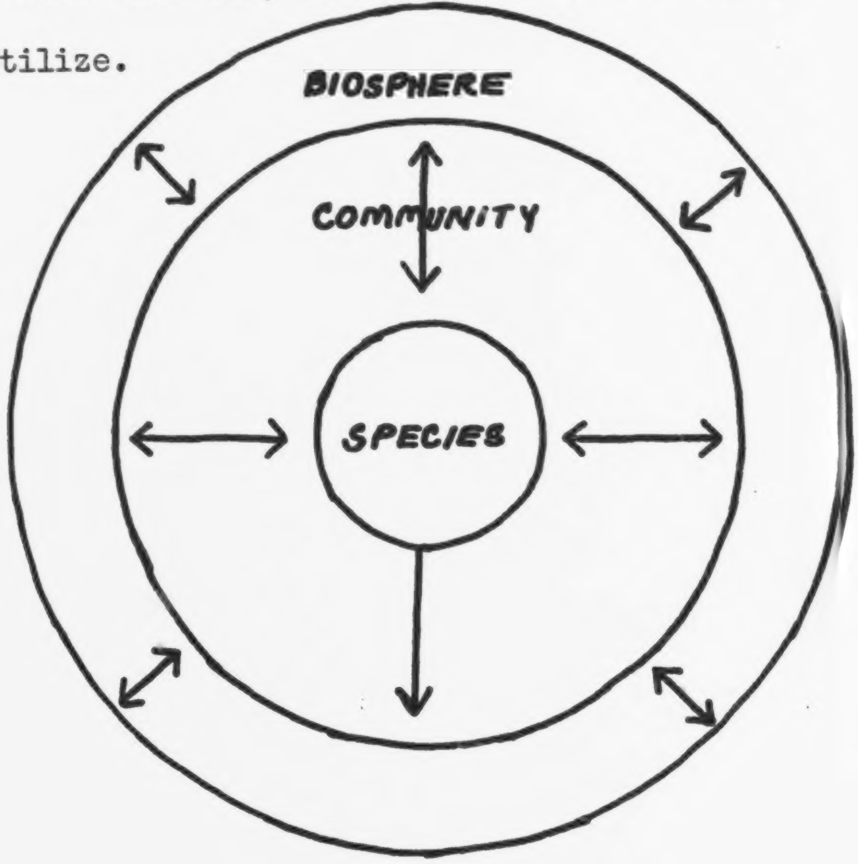
Other Organisms

All organisms are influenced in various ways by other organisms -

both those now living and those that lived in the past. We can recognize four such influences upon any organism:

1. Influence by ancestors
2. Influence by others of its kind (which will introduce us to another level of organization - species.)
3. Influence by different species of organisms with which it lives (which will introduce us to still another level organization - the community.)
4. Influence by the most distant (geographically speaking) organisms on the earth, (the entire world of life - the biosphere). The biosphere includes all living things on the earth. Each of them affects all the others, directly or indirectly, for all of them are a part of the balance of nature: all take part in the cycles of nature and form the food web.

Balance in nature also includes the change of chemical substances to living things back to chemicals. Green plants change chemicals such as minerals, carbon dioxide, and water into foods. Animals and plants use the foods to make living tissue. As animals breathe, carbon dioxide is restored to the atmosphere. Bacteria, feeding on dead plants and animals, change compounds back into minerals, carbon dioxide, and water, which plants, in their turn, utilize.



Activities

1. Try to find out, by watching, what niche some animal fills in a plant-animal community.
2. Try to work out for yourself some food web in your invironment.
3. Examine with a microscope some of the green scum which forms on the walls of an aquarium. The scum is made up of very tiny green plants. Such plants form the first link in many food webs.
4. Make a list of ten kinds of animals common in your region. By watching them, try to find out whether they are carnivores, herbivores, or omnivores. Check your conclusions by using reference books.

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CHAPTER X

Objectives

Assuming that man desires to live abundantly in the future, what practices should be initiated and maintained to insure that he will have an adequate spectrum of resources in somewhat near adequate quantity?

What is the nature of our heritage of resources?

What is being done and what could we recommend toward preserving existing resources of all kinds?

Do our projected needs indicate the necessity of starting a program for the redevelopment of certain renewable resources?

Is there a need to look for ways to make more prudent use of resources on personal, local, national, and international levels?

What can I do to insure myself there will be raw materials available for food and the manufacture of goods in the future?

Recognize Our Natural Resources

I. A. What are indestructible resources? They are those resources which are not changed permanently to unusable substances. Examples:

1. The Sun - it is estimated that it will continue to furnish energy for about five billion more years.
2. The Air surrounding the earth - pollutants in the air tend to settle or become dissolved in precipitation. Plants use CO_2 and release O_2, animals use O_2 and release CO_2. This replenishment of the constituents of air coupled with the constant churning of air in circulation means that air is not changed permanently.

3. The Water in oceans, clouds, air, and on and under the earth's surface - constantly recycles.

4. The Stable metals such as gold and platinum - are reused.

B. Water - an indestructible resource. Why is water necessary for all life?

1. It is:

Essential for life;

Necessary for all of the life functions;

Called the universal solvent;

Necessary for cooking and useful for cleanliness; and it is needed in industry and science.

2. It provides man with:

a. Sustenance,

b. Transportation,

c. Electric power, and

d. Recreational facilities.

3. Three-fourths of the earth's surface is covered with water.

II. Other resources may be classified as nonrenewable and renewable.

A. Nonrenewable resources are those which when used are changed so that they cannot be reused in any conceivable length of time that would be meaningful to man. Examples are:

1. Petroleum,

2. Coal,

3. Natural gas,

4. Most minerals and metals, and

5. The fine rock particle portion of soil.

Nonrenewable resources cannot be replaced and have no capacity to maintain themselves.

B. 1. Renewable resources differ from other resources in that they are alive and have the capacity to replace and maintain themselves. Examples are:

1. Forests,
2. Farm crops,
3. Livestock,
4. Wildlife, and the humus and mineral portion of the soil.

2. Soil - a nonrenewable resource and renewable resource.

   1. Much of the life that sustains us depends on the soil.
   2. That part of the earth's soil which is composed of minerals and dead organic matter can be replenished by adding minerals and plowing under legumes, straw and grass. Once top soil has been washed away, it takes more than one hundred years to develop an inch of replacement top soil if parent material is exposed. Subsoil is usually composed of much smaller particles of rock called clays. These particles are so small that water is held in colloidal suspension and is not available in quantity for the support of optimum growth of crops. Clay subsoil will not by its nature develop into a replacement topsoil. No practical methods have yet been developed to convert clay subsoils into rich topsoil. The loss of topsoil can be seen to be virtually a nonrenewable resource. If the fertility or humus content of soil is depleted, minerals and organic matter can be added by reasonably fast known and practical methods. Mineral and humus content of the soil is therefore a renewable resource.

3. Given parent rock, how are the rock particles we call soil formed? Changes in temperature, winds, plants, animals, and water cause rocks to be broken down into small particles.

   Water: flowing over rocks dissolves away some of the more soluble parts of rocks. Water freezes in crevices, and in doing so, pressure develops which cracks the rocks into smaller pieces.

   Winds: blowing sands and other soil particles would continually chisel away the rock surfaces.

   Temperature: causes expansion and contraction of rocks which eventually breaks the rocks into small pieces.

4. The following processes help to build the fertility and humus content of soil:

   Decay of organic matter;

   Rain brings down dissolved nitrogen and other gases;

   Legume plants take nitrogen out of the air and fix it into nitrates for the use of plants; and

   Earthworms swallow particles of the soil, take out what they need for food, and crawl to the surface to deposit the wastesoil.

C. Forests are renewable resources. Mankind's needs for woodlands has been restricted by his needs for forest products, his need for cropland, his need for roads, and his need for room for industrial use and dwellings. Now that forests are less abundant, their value is more apparent. Much progress has been made in balancing the consumption and production of timber in the last twenty years. However, large quantities of forest products are still purchased from Canada.

1. Some uses of forests are to supply:

a. Timber for lumber and wood products;

b. Pulpwood for making paper;

c. Cellulose for rayon;

d. Bark for tanning leather;

e. Gums;

f. Resins; and

g. Turpentines.

D. Wildlife above species maintainance levels is a renewable resource. When environmental changes destroy the checks and balances of the ecosystem supporting wildlife, whole populations of species can be eliminated in the area. If representative ecosystems are not established and maintained, man will see extinction hundreds of species now in dire stress. As man's needs for space and food increase, this problem will become more acute. Many animals have become extinct because of man's irresponsible actions. During the past 2,000 years, over 100 birds and mammals have become extinct. The rate of species extinction is accelerating at the present time.

SOIL

The soil nourishes nearly every living thing on earth. Teeming with life on which most other life depends, a teaspoonful of apparently inert soil may contain five billion bacteria, a million protozoa, two hundred thousand algae, and countless fungi. Around these tiny beings a host of earthworms, roots, insects, and larger animals constantly churn through the earth like the traffic at a busy intersection.

The soil lies upon the earth much as does the rind upon an orange.

But the "rind" of soil is not uniform everywhere; it is twenty or more feet deep in places like the Florida Everglades, less than an inch thick in sections of the Canadian Shield where the glaciers have scraped the rocks bare. It is usually thickest at the Equator, and thins out toward the poles. Its color may be red, as in Western Oklahoma, or black, as in Kansas. It may be sand or shale or clay, or fit any one of hundreds of soil classifications. But always, it is the sole link between the lifeless earth and the teeming world on its surface.

Landslides may launch particles of soil, the grinding of rocks and glaciers may move soil, and the winds may catch and sweep soil for miles. The soil that now lies upon the continents is merely at its present resting stage, momentarily pausing and giving sustenance before taking its long journey once again. A mountainside is a busy place, soil particles coming and going, grains dislodging each other, and rubbing together like sandpaper. With time, there are few substances on earth too hard to be broken down into what may ultimately become soil.

The rocks must endure all ordeals of nature. The sun heats them to tremendous temperatures during the summer day, expanding the minerals lodged there; then at night, the coolness contracts them. Repeatedly carried on over decades and centuries, the strain of expansion and contraction splits off pieces of rock; even the bulkiest must soon crumble.

Although the outside of a rock may be hot to the touch, a few inches inside, toward the core, it is still cold. This is because rocks are poor conductors of heat. Thus, the outside layers expand and contract more than the core, eventually flaking off. Geologists call this "onion weathering" and it is very apparent in the deserts, where the relentless sun expands the rock skin to the limit, and the sudden temperature drop at night contracts it so quickly the upper layers are "snapped" off. At night in the desert, mountains may be heard making sounds like rifle shots. They are nature's artillery, shooting off bits of rock that someday will become soil.

Larger fragments of rock, broken off by physical weathering, are further fractured. When small rock chunks reach creeks and rivers they are rolled along by the water and ground into even finer particles. A bend in a river is nearly always laden with sand or gravel, because a stream slows there and drops its load of heavier soil particles. During floodtime, when the stream leaves its course, it spreads the deposited grains further inland. On the deltas and flood plains of most rivers, masses of particles are built up as they are drawn from a drainage area that reaches out thousands of miles into the very heart of the continents. Each year the Mississippi River dumps about 525 million tons of soil and rock fragments into the Gulf of Mexico. This means that about every 7500 years, a foot of soil and rock is removed over the entire drainage basin of the Mississippi, yet it is renewed somewhat as more parent material turns into soil.

The soils deposited by river systems are known as alluvial. Alluvial soils are among the richest on earth. The high fertility of these soils is due to the fact that the particles were drawn from diverse areas, with a whole range of rocks and minerals to provide large amounts of the essential materials necessary for plant growth.

Not only must the rocks submit to destructive physical forces, but there are chemical ones as well. The rainwater that falls upon the rocks, and flows over them is by no means pure. As it falls, it picks up some carbon dioxide from the air which dissolves and forms carbonic acid. Included in the rain that spatters upon the rocks are acids powerful enough to etch away limestone and in time form limestone caves.

Finally, the forces of life itself create soil. Rocks are broken apart by the growth and expansion of roots in crevices and are also dissolved by acids secreted from the roots. The roots continue to carry forward the life of their piece of earth by bringing up water from the lower regions of the soil, water containing dissolved minerals, some of which eventually lodges in the leaves. When the leaves fall and decay, the minerals, formerly from the depths, are then deposited on the surface of the soil. The giant oak in a meadow, which appears to be the very symbol of rest, is working actively underground to replace used minerals.

The vegetation of this planet is not merely living off the stored-up fertility of the soil; it is constantly adding to the soil. Scientists have filled a tub with a weighed amount of earth and planted a tree seedling in it. After 5 years they found that tree was about 200 pounds heavier than when planted, but the soil had lost only a pound or two. Where did the tree gain its bulk? From the sun, air, and water used during its growth. So when the tree dies, it returns to the earth not only the elements it obtained directly from the soil, but also the new supplies it manufactured. Vegetation thus can add to soil fertility.

A mass of splintered rock particles, worn to tiny fragments and then deposited in the lowland, is still not living soil. It will not become living soil until life has been added to it. The living things make the difference between a mere mass of mineral particles and a living mineral soil. The soil community consists of a web of interwoven living things, each in some way related to the other. The living organisms depend on the soil, and the fertility of the soil is dependent upon the organisms that live in it.

Soil contains a mixture of many materials, such as small rocks, organic matter, tiny plants and animals. The uppermost layer is the topsoil. The organic matter in soil is known as humus. Fertility of the soil depends on the presence of humus. There are three main types of soil. The difference in the types is due to different amounts of the various materials in the soil. Sandy soil contains mainly sand mixed with some clay and humus. This type of soil is very porous, allowing air and water to enter. Clay soil is a hard packed, nonporous soil consisting mainly of clay, some humus, and other materials. Plants do not grow well in this type of soil because very little water and air can be reclaimed from clay soil. Loam is the most productive type of soil for plant growth. It is a mixture of clay, sand, and humus. (See drawing on next page.)

References:

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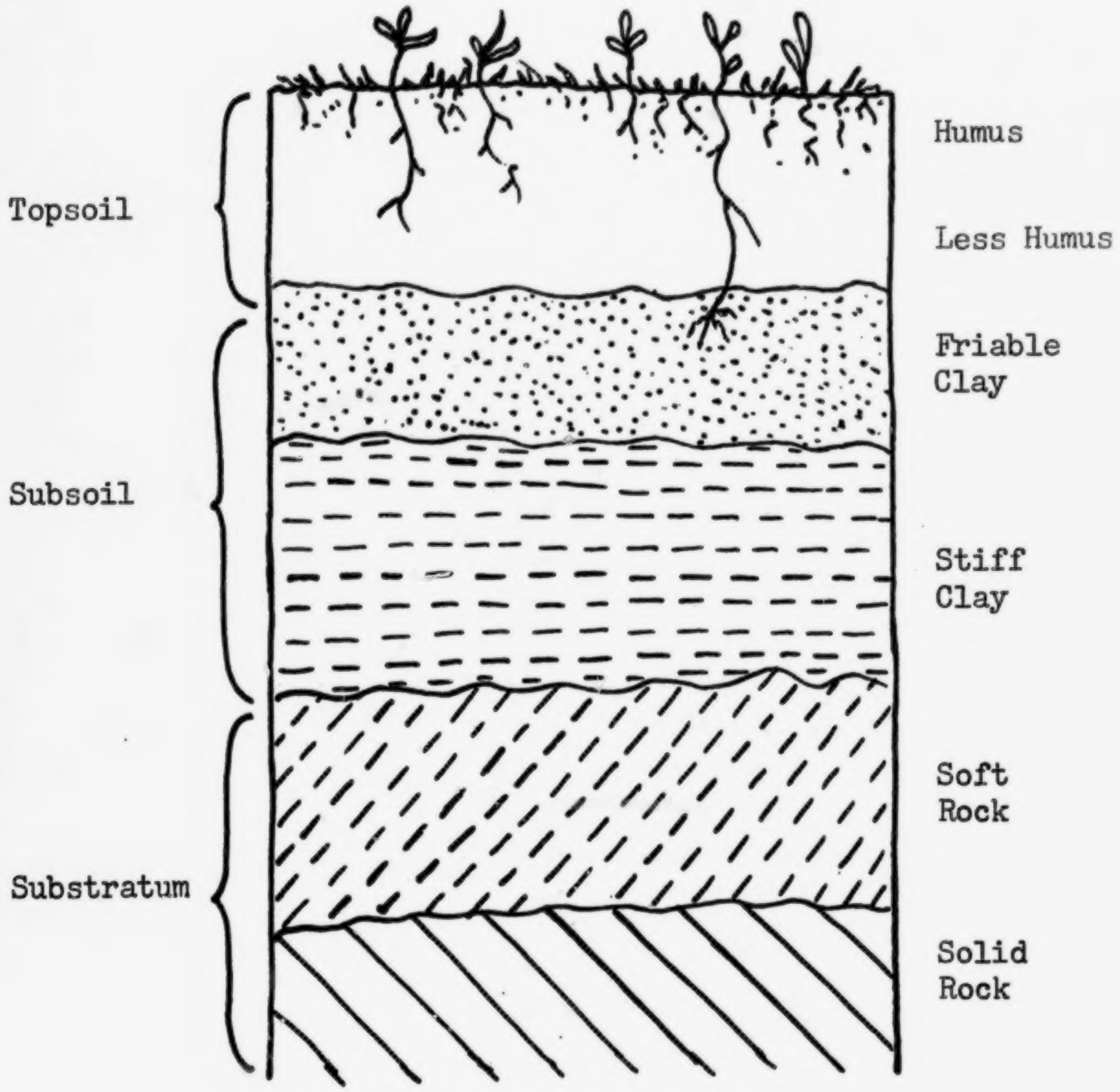
Sneg

PROFILE OF CECIL SANDY LOAM


Topsoil
Subsoil
Substratum
Humus
Less Humus
Friable Clay
Stiff Clay
Soft Rock
Solid Rock

Experiences with Erosion

To Learn About Any Stream in Your Area.

Why does this stream run in the direction it does? Is it a slow-running stream or a swift one, and why? Is yours a region with a great deal of rainfall or only a little?

Experience: To show that raindrops move soil.

Fill flat pans with soil, pat it down tight, and place several small flat stones on top. Set them in a rain and observe at intervals of half an hour, as long as the rain lasts. A sprinkling-can could be used for rain in case of necessity. What happened to the soil? If this experiment is done inside a schoolroom, the pan of soil should be set in a larger container because of the splash.

SOIL ACTIVITIES

Making Soil Artificially

A. By Friction

Purpose: To show how some of the forms of nature break down rocks into soil material.

Equipment & Material: Two pieces of limestone or sandstone (If these are not available, use building bricks or concrete.)

Procedure: Take a rock in each hand and rub together.

Results: By rubbing the two pieces of rock together, small particles will be broken off. This is not soil, but the beginning of a soil formation.

Conclusion: This demonstration shows that the formation of soil begins with the breaking up of rocks into small particles. This process usually takes long periods of time.

B. By Heating and Cooling

Equipment & Material: Several pieces of limestone, 1 hot plate, 2 pie plates, 1 pair of tongs.

Procedure: Place the pieces of limestone in one of the plates and heat thoroughly. With the tongs, take a piece of the limestone and quickly drop it into the water in the other plate.

Results: The limestone will break into smaller pieces.

Conclusion: In nature, the heating and cooling processes play a part in the breaking down of rocks into the beginning of a soil formation.

C. By Chemical Action

Equipment & Material: 1 hot plate, 1 cup of vinegar, 1 wide mouth fruit jar, several pieces of limestone.

Procedure: Place the limestone in the jar, cover it with the vinegar about one inch above the limestone. Place this on the hot plate and heat.

Results: Bubbles will form and will be released from the limestone.

Conclusion: These bubbles are carbon dioxide gas which was released from the limestone because of the chemical action of the acid in the vinegar on the rock. When you put the limestone in vinegar, you were duplicating in a small way what plants do. Plant roots take in oxygen from the soil air and give off carbon dioxide gas. This gas is one of the important end products in the decay of organic matter. Carbon dioxide gas dissolves in the soil moisture, forming weak carbonic acid. This acid reacts just as the acetic acid in vinegar did with limestone rock and will decompose limestone, marble and other rocks. Nature is continually carrying on chemical decomposition of rocks.

Influences of Fertilizer on Plant Growth

Purpose: To show how fertile soil increases plant growth.

Equipment & Material: 2 quart size flower pots, 1/8 teaspoon (level) of complete commercial fertilizer, 2 soil samples low in plant food, 8 bean seeds.

Procedure: Put a sample of soil into each of the flower pots. Put 4 bean seeds 3/4 inch deep in one pot. In the other pot, mix the fertilizer thoroughly with the soil and then plant the bean seeds 3/4 inch deep. Keep the soil moist and in sunlight.

Results: If the samples of soil are low in plant food, you should see quite a difference in the plants. On soils in good condition, you will probably see less difference.

Conclusion: Soil furnishes plant food, but because the soil has had plant food removed from it, the addition of fertilizer helps to replenish this plant food.

Note: For best results, take 2 to 4 weeks for this demonstration. The same principles of this demonstration may be used in carrying on other demonstrations with fertilizers. This may be done by using nitrogen alone, phosphorus alone, potassium alone or various combinations.

We Concede That Rich Soil is Teeming With Living Structures

Assign several student teams to take a chunk of good topsoil, preferably from a fence row or other undisturbed place. Carefully dissect this chunk of soil with a small spatula or knife and place any insects in a small bottle. Prepare several slides from each part of the soil and examine them under a microscope. Put some of the humus in a bottle and place it in a dark, warm place. A mold which develops from the decaying leaves may be studied under a microscope.

It is amazing how much life there is to be found in a small chunk of topsoil. It is these small life forms which make the soil fertile. It is always to be remembered that in conservation it is life forms that make the soil fertile, and that fertile soil can only be built around life forms.

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Soil and Water Conservation Activities for Boy Scouts. U. S. Dept. of Agriculture, P A 348.

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UTILIZE NATURAL RESOURCES INTELLIGENTLY

Water

I. Definition

The three states of water

1. Solid - ice
2. Liquid - water
3. Gas - steam

II. The Importance of Water

Water is essential to life. It is a necessary part of all protoplasm. The human body is about 65 per cent water and human blood about 90 per cent water. Water is not only important as a substance in which materials dissolve, but is also important in the chemical reactions that take place in protoplasm.

Water is one of the raw materials used by green plants in photosynthesis. It is called the universal solvent because it dissolves most substances. Water is needed for the chemical activities that take place in living things. It is the medium for transport in all living systems.

Minerals necessary for plant growth can be taken from the soil only when dissolved in water. Water is necessary for cleanliness and cooking. It is used in industry and science. Water provides man with transportation, electric power, and recreational facilities.

III. The Sources of Water

The soil acts as a reservoir for water. Rain water soaks into the ground through spaces in the soil until it reaches a layer of clay, shale, or rock which it cannot penetrate. The water collected above this bedrock or dense soil is called ground water. The top level of ground water is called the water table. Ground water is brought to the surface through springs, wells, seepage, and underground streams. Water that accumulates as a thin film around soil particles is called soil water.

About three-fourths of the earth's surface is covered with water. Most of this water is in the ocean, lakes, ponds, and reservoirs. Streams that carry large amounts of water are often dammed to create artificial lakes. Rainfall and melting snow replenish the water supply of such reservoirs.

Sources of city water are various. Some large cities pump water from rivers and must spend much money in purifying water and in lifting it high enough to supply the hilly parts of the towns.

IV. Uses of Water

Industry

Industrial water may be used for: thermal generation of electric power, cooling, a solvent, a raw material, a diluent, a waste carrier, a carrier of powdered coal, and a medium energy transfer.

Irrigation

Irrigation is needed in many climatic regions, - the Wet and Dry Low Latitudes, Low and Middle Latitude Deserts. Wherever there is a dry season, especially if the weather is warm at that time, irrigation is an enormous advantage.

About three-fourths of the irrigation water comes from streams and lakes, with wells and springs accounting for most of the remainder. Of the total water taken for irrigation in a recent year, approximately one-fourth was lost by evaporation and seepage on the way to the farm. But irrigation water lost by seepage is not entirely useless, because after sinking into the ground it may return to wells and once more enter irrigation ditches.

Recreation

Reservoirs, lakes, and dams are built to provide man with recreation. Fishing, boating, and swimming are types of recreation.

V. How Water is Conserved

Water Conservation

Excess runoff of water is normally prevented by the vegetation that covers the land. The forest floor is covered with a spongy layer of dead and decaying leaves and many low growing plants. Such a mat prevents the water from running off too quickly, allowing it to soak into the soil. Grasses and other cover on the land slow the water down and prevent rapid runoff. Man has destroyed many of the natural controls of water by removing the forest, and by plowing lands that should have been left with cover.

Control of water movements can be accomplished by the methods used for erosion control in soil conservation. In addition, dams can be built across rivers to help hold the water. Reservoirs behind the dams store water in wet seasons and release it in dry seasons. Reservoirs provide flood control, recreational facilities, electrical power and water for irrigation.

Water is needed by growing plants. It is also needed in larger and larger amounts by people and by industries. In our country alone, industries are using more than 75 billion gallons of water each day. Some places have always had a water shortage. Wherever water is being used faster than it is being replaced, sooner or later a shortage will occur. With these facts in mind, the conservation of water is very important.

VI. Water Problem

One of the most serious problems concerning water today is pollution. Water may be polluted by sewage, garbage, and industrial waste. In doing this, man has upset the balance of nature. As a result, much plant and animal life has been destroyed. Raw sewage is even now dumped into streams making the water unfit for use for many miles downstream. This problem is being taken care of partially today by sewage treatment plants which render their outflow relatively harmless.

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WILDLIFE

Wildlife refers to all forms of living things other than man and domesticated animals.

Wildlife aids Man:

1. In maintaining the heritage of unknown value for the future;
2. In destroying harmful insects and rodents;
3. By removing dead and decaying matter from the earth's surface;
4. In new plant growth by scattering and burying seeds;
5. In providing resources of food and clothing;
6. In biological research, medicine, food, space, etc;
7. In economic value;
8. In aesthetic ways, and in recreation; and
9. In applied science as shown by the following application--using the frog, scientists and engineers have built a copy of the frog's eye, an electronic device that "sees" only objects of certain shapes. It may be used to prevent airplane collisions at busy airports.

The main causes for the decline of wildlife populations are undoubtedly the great human population expansions and the expanded land use by humans in the last 100 years or so.

Associated causes have been changes in habitats such as:

1. Unwise farming of marginal lands;
2. Excessive cutting of timber;
3. Water pollution by sewage, garbage, and industrial waste;
4. Oil pollution in coastal waters; and

5. Drainage of swamplands and wet soils which lowered the water table.

Among associated human actions unbalancing food webs were:

1. Wanton mass slaughter and bounty hunting of predators;
2. Underhunting because of lack of predators;
3. Overhunting, overfishing, and overtrapping of many species; and
4. Automobiles killing many animals.

An estimated 135,000,000 acres of land in the United States is without satisfactory tree coverage. Half of this area will be capable of restocking itself. The Forest Service will attempt to restock 25,000,000 acres in the next 20 years.

Evaluation

Which of the following ways of protecting wildlife are likely to prove fruitful, and why:

1. Improving habitats by providing cover, water, and places to raise young;
2. Building and maintaining winter feeding stations, either during emergency conditions or all the time;
3. Emphasizing or de-emphasizing bounty hunting of predators;
4. Establishing game preserves to protect diminishing species;
5. Restricting the length of hunting and fishing seasons by issuing licenses;
6. Encouraging hunting as a controlled harvest;
7. Limiting the number of game birds and animals that may be killed during a hunting season;

8. Encouraging the use of fish hatcheries as a means of restocking lakes and ponds;
9. Establishing wildlife refuges, sanctuaries, and game preserves;
10. Instituting a program of education to stress the importance of wildlife conservation;
11. Preventing forest fires;
12. Reducing pollution;
13. Selective cutting of forests at a certain age and size or complete cutting of forest with seedling replacement;
14. Expanding forest fire prevention teaching programs or prevention management research;
15. Increasing research for the control of insects that attack trees or importing the natural enemies of these insects.
16. Replacing harvested trees with new seedlings.

Conservation Pledge

I give my pledge as an American to save and faithfully to defend from waste the natural resources of my country - its soil and minerals, its forests, waters, and wildlife.

Projects

1. Arrange a field trip to a fish hatchery and report on fish raising for stocking lakes and streams.
2. Do a research project in the library on how beavers are important in conservation.
3. Make a picture chart showing the kinds of wildlife in your state.
4. Report to the class what the game laws are in your state.

5. Visit a forest ranger or a game warden. Find out about his work and how he prepared himself for his job.
6. Find out the economic value of wildlife in your state.
7. Make a study of the animals that are almost extinct.
8. Write a report on A Wildlife Refuge.

References:

1. Izaak Walton League of America, Inc., 1326 Waukegan Road, Glenview, Illinois.
2. National Audubon Society, 1130 Fifth Avenue, New York 28, New York.
3. National Wildlife Federation, 1412 16th Street, Northwest, Washington 6, D. C.
4. U. S. Department of the Interior, Fish and Wildlife Service, National Parks Service, Washington 25, D. C.
5. U. S. Department of Health, Education and Welfare, Office of Education, Washington 25, D. C.
6. State Conservation Department, Your state capitol.

WATER

Experiences

There is water in the ground.

Children may relate and discuss any of their experiences that would lead them to think there is water in the ground. They might be interested in making drawings of their ideas of underground water. Discuss what makes an artesian well flow.

Running water can do work.

Water running downhill under the force of gravity is able to transport soil, small rocks, etc. The source of the energy of running water is the agency which carried it up the hill in the first place, namely the sun.

Water has energy which is due to its depth.

Punch about four small holes, one above the other in the side of a gallon can. If the can is filled with water, the stream from the lowest hole will have more force than those from the higher holes. The water at the bottom of the can is pressed by the weight of all the water above it.

Energy is required to push floating objects under water.

Young children playing with objects in a basin of water discover that some objects float while others sink. Energy is required to sink the floating objects and to hold them under water.

Fifty years ago who would have said that a frog could be of special aid to man? How about a holly tree, or perhaps one of our night flying giant silk moths, or a lowly leaf miner insect larvae that burrows between the top and bottom surfaces of a leaf? What economic value would have been predicted for these organisms? Yet a frog from South America has been used in hospitals to make pregnancy tests for several years. The holly tree has been used for fine woodwork. The perfume exuded by female giant silk moths is being synthesized for luring several species of harmful insects into traps. It is suspected that slight modifications of the perfume may be effective with many other insects. And the leaf miner loves to attack poison ivy leaves.

It is readily evident that even a cursory review of research would reveal hundreds of new and sometimes vitally important uses for wild animals and plants that were thought useless 50 years ago. Today, research and development projects are proceeding at an unprecedented rate for all time. Much more money has been spent for research since 1950 than had been spent before 1950 as far back as history goes. Out of all the scientists that have ever lived more than nine out of ten of them are alive and working today. Why shouldn't we expect new uses to be developed for our living natural resources? Dare we cause the extinction of a species today that might just be the answer to some vital problem in some tomorrow?

What is your answer?

CHAPTER XI

How will the challenge of investigation and research help us confront the major biological problems of the world?

Objectives

1. What are some significant worldwise biological problems that not only are receiving a great deal of attention today, but also are likely to demand even more research and investigation in the future?
2. How have research and technology joined hands to wrought changes in significant biomedical problems?
3. What are some of the more challenging and promising avenues for future research?

What part can coal play in the solution of man's food needs? We can look forward to further research by people dedicated to solving the pressing larger food problems that loom on the horizon of our lifetime.

To maintain high agricultural yields it has been found necessary to employ highly potent insecticides. The concentration of these insecticides is magnified by the long-term food web effect, causing some disruption in the balance of nature. For example, DDT becomes concentrated in the insects and worms that birds help us control. The birds after eating these insects and worms further concentrate the DDT until it becomes lethal; thus, the world loses many of its natural insect deterrents. DDT is also concentrated in fish. This leads to the death of fish predators and a buildup of DDT concentration in man. Furor over these consequences has spurred insecticide research toward finding alternate answers.

Man has raised male screwworm flies in captivity, then subjected them to sublethal gamma radiation which renders them sterile. Millions of these sterile males are subsequently released to mate with wild females. These females lay infertile eggs which cannot develop. This method shows promise for future use against other harmful insects. The method is selective for the harmful species and has no residual effect.

Currently, concerted insecticide research is exploring the finding that the amount of juvenile hormone for any certain insect is very critical in certain stages of its development. An excess of juvenile hormone in larval stages, causes distortion in body development, and the insect never fully matures. Attempts are being made to synthesize juvenile hormones which demonstrate a specificity for various harmful insects.

The mating scent released by some undesirable female moths may also be synthesized for use as bait to trap males. Success, however, depends on the identification and synthesis of the mating scent specific for each harmful species.

More research has been conducted on the process of aging in man during the last 20 years than was carried on during the entire history of man prior to that time. Ways are being found to stretch man's declining years and make them more liveable. One problem still existing however, is how older people can be provided an opportunity to continue gainful employment, which may help many to retain their self esteem and mental health. Both aging and mental disease have been found to be accompanied by biochemical changes. If we can learn to prevent or lessen the effects of these changes through research, we will be able to alleviate one of the unfortunate maladies that is presently concomitant with an aging society.

Although great gains toward controlling diseases have been made through the use of antibiotics, which either retard growth or eliminate the disease causing microbes, the ability of microbes to mutate specific antibiotic resistant strains makes research in this area a seemingly never ending race. It has become necessary for us to continuously search for new basic antibiotics and to produce synthetically similar antibiotics to those already in use in order to maintain our present favorable control of microbes.

We know that the death rate has been greatly reduced by the identification and partial control of disease vectors, and the development of a spectrum of highly effective antibiotics. Were all other factors held in check, the effect of the forementioned achievement would greatly expand the world's population. However, other factors have not remained static. For many generations birthrates have been soaring on almost a worldwide basis. The overall effect has been a world population boom in the nature of a logarithmic progression.

There are 3.2 billion people in the world today, and about 70 per cent of the children in the underdeveloped countries are underfed. In 1961, it is already beyond the capability of United States agriculture to feed the world's hungry people adequately.

Some projections of world population growth, based on present rates of increase, estimate a world population of 7 billion by the year 2000. Moreover, growth rates show that the greatest increases will occur in the underdeveloped countries where hunger is already widespread. It is projected that 80 per cent of the world's population will be located in those underdeveloped countries by the year 2000.

One of the most pressing needs of the expanding world population, will be food. Even though world need presently exceeds adequate supply, the picture is not all dark. Since World War II the United States has increased its domestic food production 50 per cent, while reducing its farm labor force by 40 per cent.

Research has led to extensive use of fertilizers and the development of efficient methods to increase yields. New crops have been discovered, new varieties have been developed, and an array of new products has been created. However, with each succeeding year, the food problem has become more acute, more complex, and hence more pressing a challenge to all the world's people.

Can hydroponics contribute toward solving the world's food problem?

Hydroponics is the science of growing plants without soil by feeding them on chemical solutions. Plants can be raised in the absence of soil by providing, in water solution, the nutrients which they usually obtain from moist soil through their roots. Hydroponics is a Greek word meaning "water working." Considerable research, particularly in Japan, has been concerned with whether or not food production can be made economically feasible through the use of hydroponics. A breakthrough could swing production into high gear at any time.

Some advantages of growing crops hydroponically are the following: quicker growth; relative freedom from soil diseases; very consistant crops; excellent quality of the produce; reduction in growing area; almost complete freedom from weeds; minimization of the effects of drought; and the ability to grow plants out of season. Chemically-grown plants are not inferior to naturally reared ones with respect to flavor, and analysis has not shown any deficiency in vitamin content. The following table presents a comparison of yields per acre for several crops.

Crop	Agricultural Yield Per Acre	Hydroponic Yield Per Acre
Rice	1,000 lb.	11,400 lb.
Wheat	600 lb.	4,100 lb.
Potatoes	22,000 lb.	80,000 lb.
Tomatoes	5 to 10 tons	180 tons

Hydroponic farming may provide a solution to the food shortage problem inevitably to be faced by an increased population living in an increasingly crowded world. Not only could immense and barren lands be made productive, but crops might also be raised in sterile and arid regions that cannot presently support large human population.

Hydroponics may never replace soil agriculture, but the process has proven that on wasteland, rocks, house tops, back porches, or anywhere that sufficient sunshine and water are made available, plants can be grown to produce food.

Another approach which has helped solve the food problems of a given area has been the careful examination of all existing plant and animal species native to an ecosystem in order to determine which are the most efficient in filling local needs. Such an approach emphasizes the merit in maintaining all species of natural flora and fauna by conservation stewardship. In Central Africa it has been found, for example, not only that the native Eland antelope produces red meat at a faster rate than beef but that its milk is especially valuable because of its resistance to spoilage.

Even in America, where scientific agriculture is well developed, one finds that many new species have been put into production in the last few years. Even now a new cereal, a relative of wheat, is being developed so that it can be grown commercially. It is reputed to yield about 70 bushels to the acre, nearly twice the average commercial production for wheat.

Man is looking to the sea for more food. Although much is yet to be learned about how best to farm the sea, modern floating canneries and frozen food processing plants are plying the oceans with sonar and mechanical harvesting devices. By economically processing whole fish into fish-meal, man can produce a cheap, edible, high-protein product which starving people can utilize advantageously as a protein food if they will. However, even with all the foreseeable possibilities for increased food supplies, which may double the amount of food we are now taking from the sea, mankind is likely to be faced with an even more critical food shortage by 1975.

In an effort to help solve the world's food problems, the United States Department of Agriculture, acting through the Food and Agricultural Organization, has made food production research date available to all nations asking for them. Between 1961 and 1964, the F. A. O. presented 45,000 field demonstrations in fifteen underdeveloped countries, dealing with hybrid seeds, mechanization, weed and insect control, fertilization methods and the utilization of local plants and animals.

A dominant factor in the hunger crisis is the human body's inability to synthesize eleven of the twenty-six amino acid constituents of the proteins essential to life. The grains and vegetables presently available to undernourished nations lack certain of these eleven essential amino acids. The meat of ruminant animals could supply the missing amino acids, but the space needed to raise them and the expenditure of energy from the grain they conserve are too great to make this a practical solution in overpopulated areas. Recently the missing amino acids have been produced from selected strains of yeast grown in waxy gas oil mixed with water, nutrients, and bubbles of oxygen. The nutrients are ammonia salts, phosphorus, potassium, growth vitamins, and the trace elements found in general-purpose fertilizers. It has been calculated that 20 million tons of pure edible protein can be processed each year from 40 million tons of petroleum. This is more than three times the annual harvest of ocean protein. If the one pilot plant now in operation proves economically flexible, it will be possible immediately to effect full production; for there are more than 700 refineries around the world that could readily be modified to produce the petroleum yeast protein. Thus, petroleum promises at least part of the answer to the world's immediate hunger problems.

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CHAPTER XII

How can knowledge and skill in biological science help me live securely in the world of tomorrow?

When all scientific findings are accepted as tentative knowledge subject to further investigation, new findings become fresh exciting clues in the never ending quest for a closer relationship with the truth about everything biological within the biosphere and within man's experience.

When the researcher attains the knowledge of how to construct and carry out a competent research design, his ability and confidence will also grow toward meeting the challenge of the unknown in the future.

EARTH SCIENCE

CHAPTER I

A FIRST LOOK AT THE EARTH

UNIT I. THE PLANET EARTH

1.1 How do I know the earth is round?

For thousands and thousands of years, man relied upon his eyes and imagination as he studied the universe. In using his imagination, many false ideas developed even though much truth was learned.

People of long ago pictured the earth as a flat tray supported on the back of three elephants; the elephants were standing on the back of a huge tortoise.

Thales, a Greek philosopher, taught that the earth was a short cylinder floating on a vast ocean of water. The people were supposed to be living on the flat top.

There were many more ancient beliefs about the shape of the earth. It was not until 580 B. C. that a Greek philosopher, Pythagoras, stated that the earth's shape was a sphere.

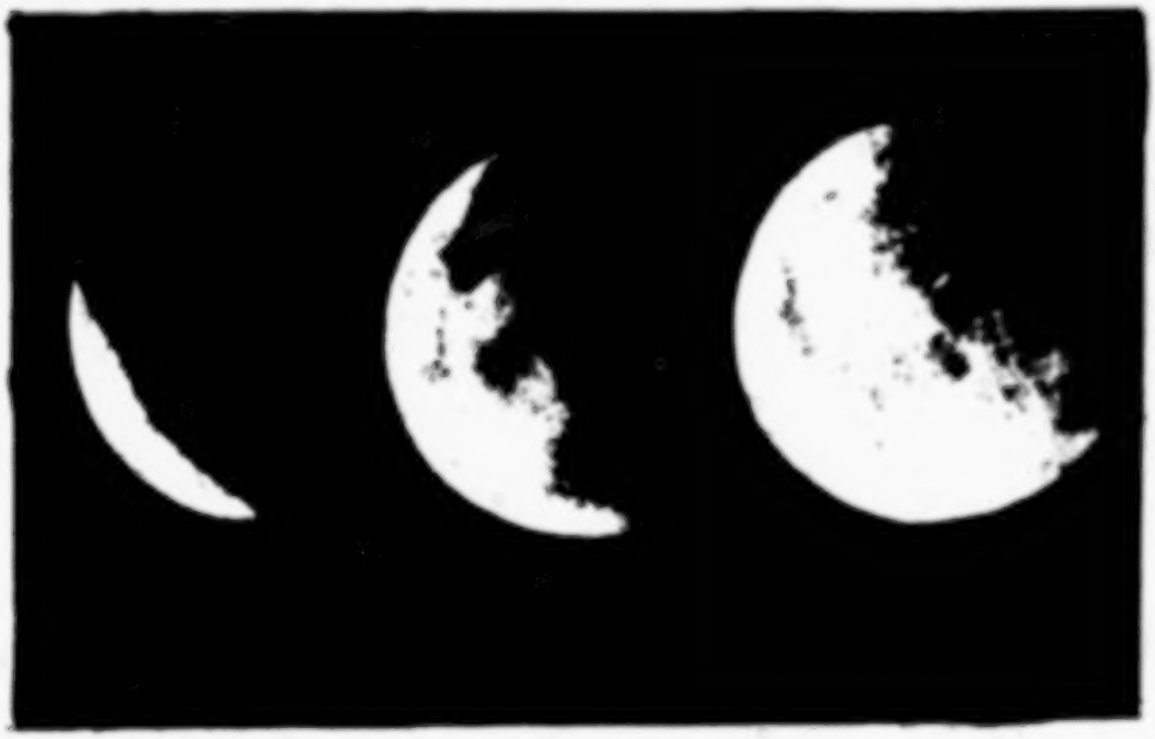
Through the years facts were discovered about the shape of the earth. In 1492 Columbus' travels helped to prove that the earth was round and not flat, as some people believed.

There are many complicated methods of determining the shape of the earth. Many of these methods use higher mathematics and other forms of study.

We will try to first give evidence that the earth is not flat and then show that the earth is an oblate spheroid.

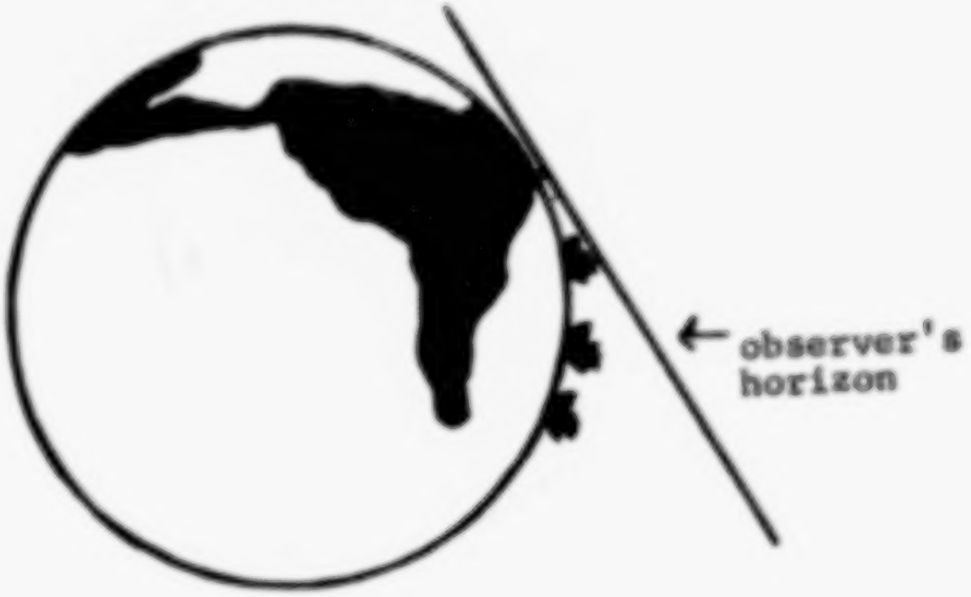
Lunar Eclipse

During a lunar eclipse as the moon enters or emerges from the earth's shadow, the shape of the shadow seen on the moon is always round. Although certain projections of a cone are circular, only a nearly spherical object produces a round shadow under all circumstances. If the earth were a disk, for example, there would be some occasions when the sunlight would be striking the disk edge only, and the shadow on the moon would be a line.

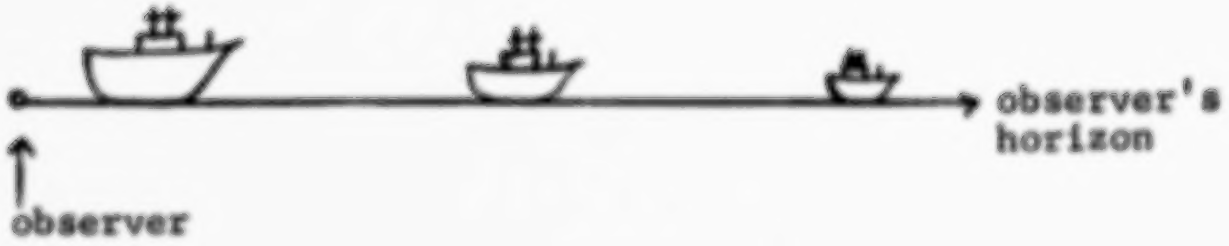


The partially eclipsed moon moving out of the earth's shadow. Notice the curved shape of the shadow.

Anyone who has observed a ship disappearing at sea has evidence that the earth is not flat. As a ship sails away from shore it seems to sink gradually below the horizon. The hull disappears first, then the cabins, and finally the mast. If the earth were flat, the ship would not start to disappear with the hull first. It would disappear by becoming smaller and smaller, because of the distance. This is indicated in the following diagrams.



A ship gradually disappears below the horizon.

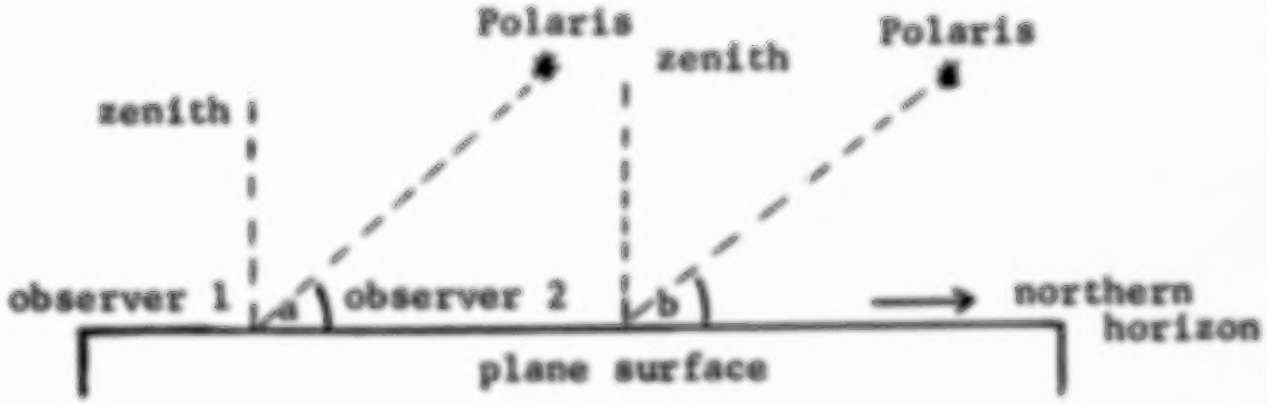


On a flat surface the ship would simply become smaller and smaller due to distance.

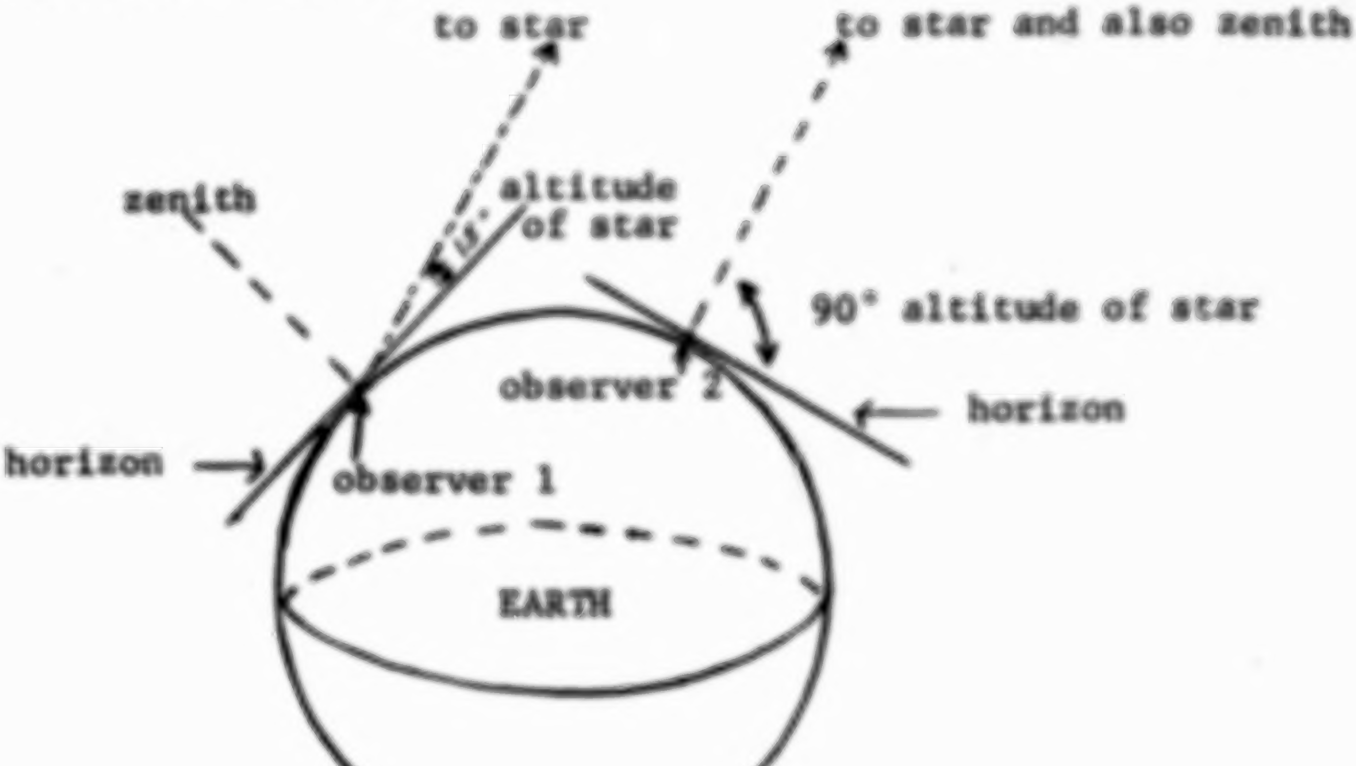
The evidence above shows that the earth is not flat. It does not prove that the earth is a sphere. It is important to understand the difference between evidence and proof.

To determine the shape of the earth one can turn to a method used by sailors and navigators to locate position. This method is based on an observer locating the position of a star as seen from his observation point, and upon the fact that any star is so far away that any two observers looking at the same star at the same time must be looking in the same direction regardless of their separation on the surface of the earth. As an example, if an individual in New York City and an individual in Huntsville, Texas both look at the North Star (Polaris) their lines of sight can be considered parallel.

If the earth were flat and the two observers simultaneously looked at the same star, they would find it had the same altitude regardless of their positions.


Polaris
zenith
Polaris
zenith
observer 1
a
observer 2
b
northern horizon
plane surface

Since the earth's surface is curved, the two observers would find different angles of altitude for the same star observed at the same time.


to star
to star and also zenith
zenith
altitude of star
15°
90° altitude of star
observer 2
horizon
horizon
observer 1
EARTH

Two observers sighting the same star at the same time

If this were continued for many different locations it would show that the earth is shaped something like a ball. If the rate of curvature were constant then one could say that the earth is a true sphere. We now know, of course, that the earth bulges slightly at the equator and is thus an oblate spheroid and not a true sphere. The difference between its polar diameter and equatorial diameter is only about one part in 300. So small a difference is not easily discerned by the eye.

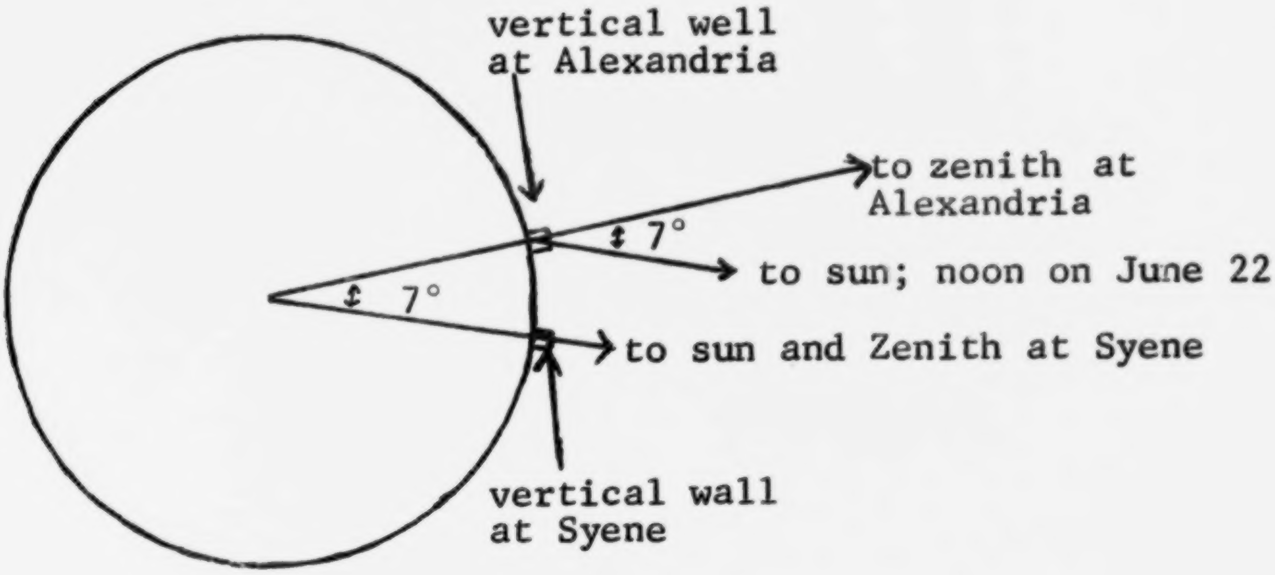
In studying the shape of the earth one should always remember the size of the earth. A person cannot see the roundness of the earth because the earth is too large and, as an observer, you are too close to observe its shape. An observer can easily see the roundness of the moon because of our distance from it. Were we on it, its shape would not be so easy to determine.

1.2 How can I measure the circumference of the earth?

The circumference of the earth was a mystery to man during the early ages. It was not until 276 B. C. that the circumference of the earth was determined. Eratosthenes, an astronomer, used mathematics to determine the circumference or distance around the earth. The method he used was to measure the angle of the noonday sun near two Egyptian cities, Syene and Alexandria.

Near the city of Syene, Eratosthenes found that at noon a full and complete reflection of the sun could be seen in the water at the bottom of a deep well. This reflection of the sun meant that the sun was directly overhead. The sun's rays were aimed at the center of the earth. In Alexandria, 570 miles due north of the well, Eratosthenes measured the angle of the sun's rays as shown by the shadow of a vertical post in the ground. At this point, the angle of the sun was found to be about seven degrees. Eratosthenes used the distance between the two cities and the angular difference of seven degrees to arrive at a figure for the circumference of the earth. He found the distance around the earth to be 250,000 stadia; a stadium is believed to be about one tenth of a mile. This would make the circumference of the earth about 25,000 miles. Unfortunately, this and other learnings were disregarded for centuries.

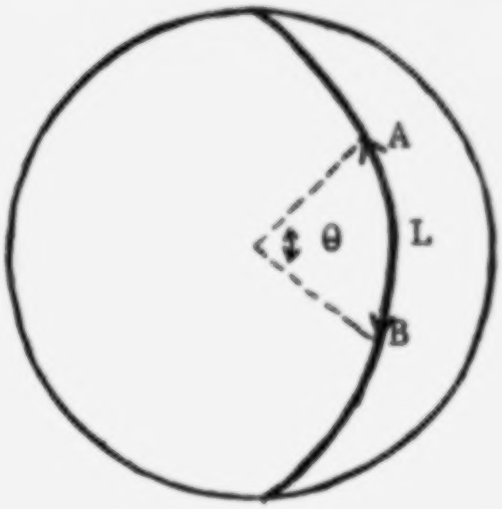
Astronomers using new methods and instruments have determined that the earth's circumference is 24,902 miles. The earth, with a circumference of 24,902 miles is fifth in size compared to the other planets of the solar system. It is one of the smaller planets, the diameter being 7926 miles through the poles and about 27 miles greater at the equator, because the earth's rotation has caused a slight bulge there.


vertical well
at Alexandria
to zenith at
Alexandria
7°
to sun; noon on June 22
7°
to sun and Zenith at Syene
vertical wall
at Syene

Eratosthenes' experiment to determine the earth's diameter

Modern methods of determining the circumference of the earth are essentially the same as outlined above. The problem is simply to determine the linear distance between two places on the surface of the earth and the angle between the lines joining these places to the center of the earth.

Referring to the figure on the next page, suppose two places are L miles apart, and the angle at the center of the earth between the two radii is θ. Then we can write $\frac{C}{L} = \frac{360°}{\theta}$ or the circumference $C = \frac{L \times 360°}{\theta}$.



Relation between arc length (L) and angle (θ) on a sphere

We have previously mentioned that the earth is an oblate spheroid. Consequently, the arc length of a degree varies slightly over the earth. At the equator one degree is equal to 69.16 miles, and decreases slightly as one moves toward the poles. Thus the circumference at the equator is 69.16 x 360 = 24,902 miles. The diameter can be found by using $C = \pi d$, therefore $d = \frac{24,902}{\pi} = 7927$ miles.

Objectives

1. How have astronomers been able to approximate the circumference of the earth?
2. How can we realize the shape of the earth by observations?
3. How have our beliefs changed concerning the shape of the earth?
4. How have new methods helped in determining the circumference of the earth?

Activities

1. Have students bring satellite photos showing curvature. Post on bulletin board and identify source, location, and other items of interest.
2. Have the students make reports on early beliefs concerning the shape of the earth.
3. Have the students make a file on famous astronomers. Give one accomplishment of each.
4. Write to N. A. S. A. for pictures taken from space ships.

Size, Shape, Distance

5. Two balls representing the earth and the moon can be used to show both size and distance to the same scale. Secure two balls--one about four times the diameter of the other. The average classroom globe and a baseball are about the right proportion. If the earth's diameter of 8,000 miles is represented by a globe one foot in

diameter, then the moon's diameter of 2,000 miles would be three inches (the baseball) and its distance from the earth (240,000 miles) would be thirty feet.

Ask a child to hold the globe at one end of the classroom. Fasten two thirty-foot pieces of string to the baseball and run one to each side of the globe. This will form a slender triangle, two sides of which represent the lines of sight to observers on opposite sides of the earth. Can you see how the angle of the observer's lines of sight can be used to determine the distance from the earth to the moon? It will amaze children that the moon is really so far away, when their books and commercial models show it comparatively nearby.

Now ask another child to hold the tiniest object he can find (whatever he holds will be too large) about two or three inches from the surface of the globe. This will represent the size and distance from the earth of the first artificial earth satellites. How do they compare to the natural satellite--the moon?

Measuring Distance

6. To show how men measure distances by displacement, hold a finger in front of your face and line it up with a distant object. Close one eye and your finger shifts against the background. Men use the same principle in the range finder, and in finding the distance to planets and stars.

EVALUATION

1. Do students have a clearer conception of the shape of the earth?
2. Did the students understand the principles used in determining the shape of the earth?
3. Was it a challenge to the students to find out more about the circumference of the earth?
4. Does the unit lead to functional understanding of the size and shape of the earth?

1.3 Are there methods of determining the mass, volume and density of the earth?

A. Definitions:

1. Volume--a measure of the amount of space that matter occupies
2. Density--the mass per unit of volume
3. Mass--the quantity of matter making up an object

B. Methods of determining the mass, volume and density of the earth.

1. Volume--a sphere, whose cross-section is a circle, contains 41,253 square degrees. The volume of a sphere is equal to 4/3 r^3 cubic centimeters (cm^3), where r is the radius of the sphere in centimeters. The shape of the earth is that of an oblate spheroid only slightly flattened at the poles and having a symmetrical equatorial bulge. The degree of polar flattening is measured by oblateness of the spheroid, which is defined:

$$\text{oblateness} = \frac{\text{equatorial radius} - \text{polar radius}}{\text{equatorial radius}}$$

Since the oblateness of the earth is small, the volume of the earth may be calculated with sufficient precision on the assumption that it is a sphere of

$$\text{radius } R = 6400 \text{ Km.} = 6.4 \times 10^8 \text{ cm.}$$

This volume is $V = 4/3\pi R^3 = 4/3\pi(6.4 \times 10^8)^3$, or

Volume of earth = 1.1×10^{27} cubic centimeters (cm^3)

2. Density--Formula

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{6.0 \times 10^{27}}{1.1 \times 10^{27}} \quad \text{or}$$

Average Density of the earth: Density = 5.5 gm/cm^3

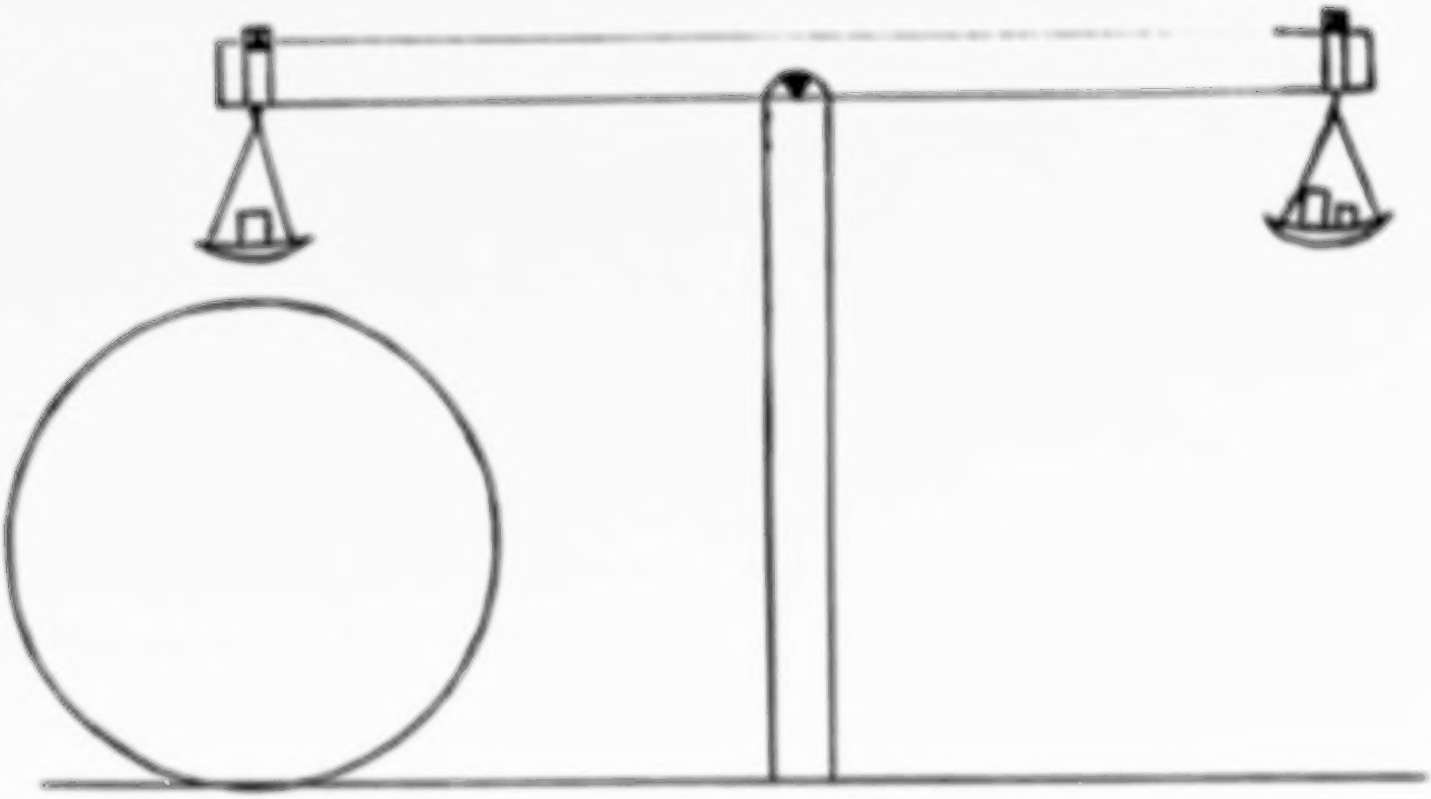
This value is substantially greater than the density of the rocks found in the crust of the earth, which is about 3 gm/cm^3; even the heaviest of the common igneous rocks have densities not greater than 3.3. Since the surface layers have a much lower density than the average density of the earth, the density of the earth's interior must be greater than 5.5.

3. Mass (mass of earth = 6 x 10^{27} grams)

There are several methods of determining the mass of the earth, but in general all of them depend upon comparing the attraction between the earth and a known mass, with the attractive force between two known mass. (Gravitational attraction will be discussed in the following chapter).

The first determination of the mass of the earth was made by Maskelyne in 1774. He suspended a small mass from a string near a large mountain, and compared the attraction between the mountain and the small mass with the attraction between the same mass and the earth. The string would swing slightly toward the mountain from the vertical position, the amount of the swing depending upon the attraction of the mountain. Maskelyne used this fact to determine the mass of the earth. Obviously, this procedure was not very accurate because the mass of the mountain cannot be determined accurately, nor how it acts gravitationally.

By means of a laboratory experiment it is possible to more accurately determine the mass of the earth. This method was first used by P. von Jolly in 1881, and by Poynting. Poynting placed two identical masses, M_1, each weighing 330 pounds, in opposite pans of a beam balance. A much greater mass, M_2 drew the pan downward, upsetting the balance. Balance was restored by adding small weights, m, to the opposite pan. Thus, the small mass, m, counterbalanced the mutual attraction between M_1 and M_2. It is, of course, the attraction between the small mass, m, and the earth, the center of which is at distance R, that equals the attraction between M_1 and M_2.



1.4 How can I uniquely locate a position on the surface of the earth?

a. Longitude

b. Latitude

A. Definitions:

1. Longitude--The longitude of a place is its angular distance east or west from the prime meridian; it is generally expressed in degrees, from 0° to 180° either way.
2. Latitude--The latitude of a place is its angular distance in degrees north or south from the equator, from 0° to 90° either way.

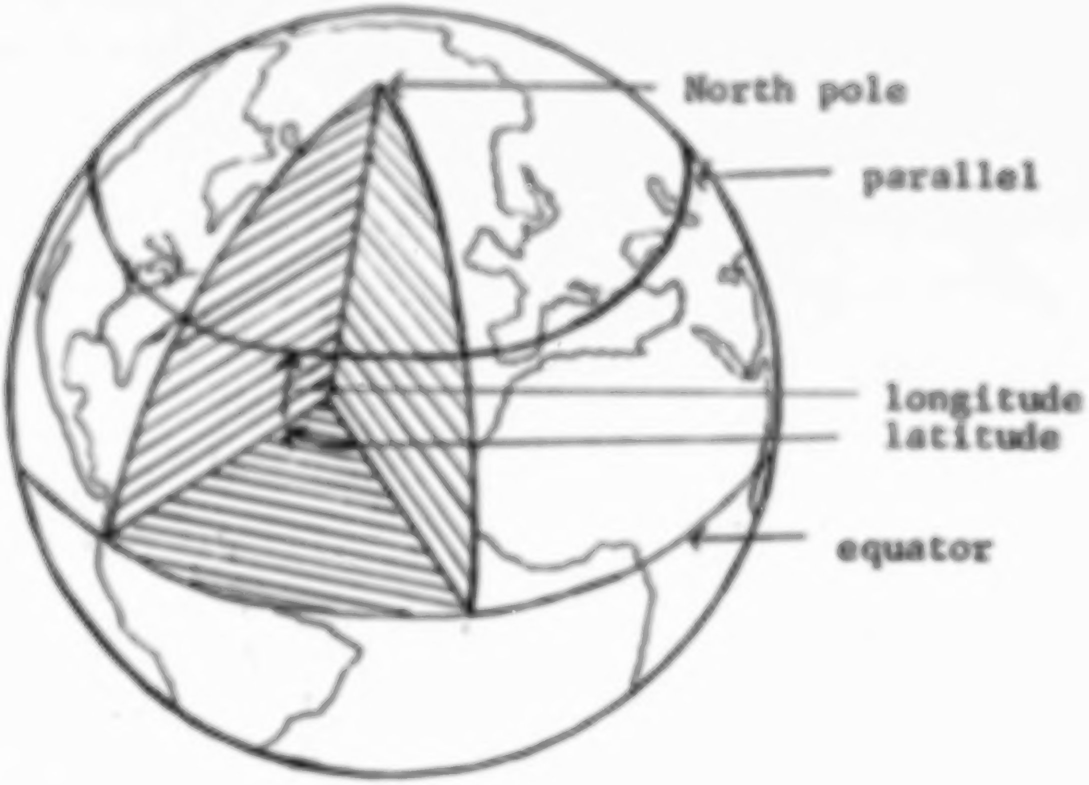
B. Introduction

Some people regard the latitude and longitude lines as being completely imaginary. However, there is a natural relationship between these lines and the earth.

As the earth rotates on its axis, the axis of rotation provides a natural basis for one reference system, longitude. Man's attempts to describe a location on the surface of the earth is hindered by its motion. As longitude is concerned with "eastness" and "westness", then the lines drawn between the poles provide a reference system that goes against the grain of the earth's rotation. Since the latitude lines are parallel to the earth's direction of rotation, they are called parallels. The degrees of latitude are about equal surface distances apart. Longitude east or west is measured in degrees also, but the surface distance between degrees diminishes. Why?

C. Longitude and Location

The earth's equator is a circle halfway between its north and south poles. Lines that run parallel to the equator are called parallels of latitude. Meridians pass from pole to pole and are at right angles to the equator. The prime meridian passes through the original site of the Royal Observatory at Greenwich, England. The prime meridian crosses the equator in the Gulf of Guinea at the point where the longitude and latitude are zero. Sailors and pilots use longitude to help determine the location of their ships and planes.


North pole
parallel
longitude
latitude
equator

Longitude and Latitude

Since the earth's axis points toward Polaris, then the latitude of any place in the northern hemisphere is approximately equal to the altitude of Polaris above the northern horizon. Lines drawn parallel to the equator both north and south are called parallels of latitude.

The space between two meridians is greatest at the equator. This space narrows as the lines of longitude approach the North Pole and the South Pole. For example, a degree of longitude at New Orleans, Louisiana, is about 60 miles wide. At Winnipeg, Canada, which lies much nearer the North Pole, a degree of longitude is less than 45 miles wide. At Fairbanks, Alaska, which is closer to the North Pole than Winnipeg, it is even narrower.

D. Longitude and Time

Once every 24 hours, any point on the earth's surface passes through a whole circle--360°. The earth turns once on its axis every 24 hours. All 360 degrees of the earth's circumference also pass beneath the sun once in 24 hours (15° = 1 hr. = 60 m or 1° = 4 m). One hour of time equals 15 degrees of longitude. Each degree is equal to 60 parts called minutes. Each minute is divided into 60 seconds.

Five units of Time equivalent to distance

Units of Time	Equivalence to distance
24 hours	360° of Longitude
1 hour	15° of Longitude
4 minutes of time	1° of Longitude
1 minute of time	15' of Longitude
1 second of time	15" of Longitude

The rotation of the earth makes the sun apparently move across the sky each day, serving as a master clock that regulates much of our outside activities. One very old method of keeping time is by the use of a sundial, and time kept thusly is called apparent solar time. To tell the time of day, one watches the position of the shadow cast by the sun on the dial. It is twelve o'clock noon when the sun reaches its highest position above the eastern horizon, and the solar day is the interval of time between two successive crossings of the sun through this highest position.

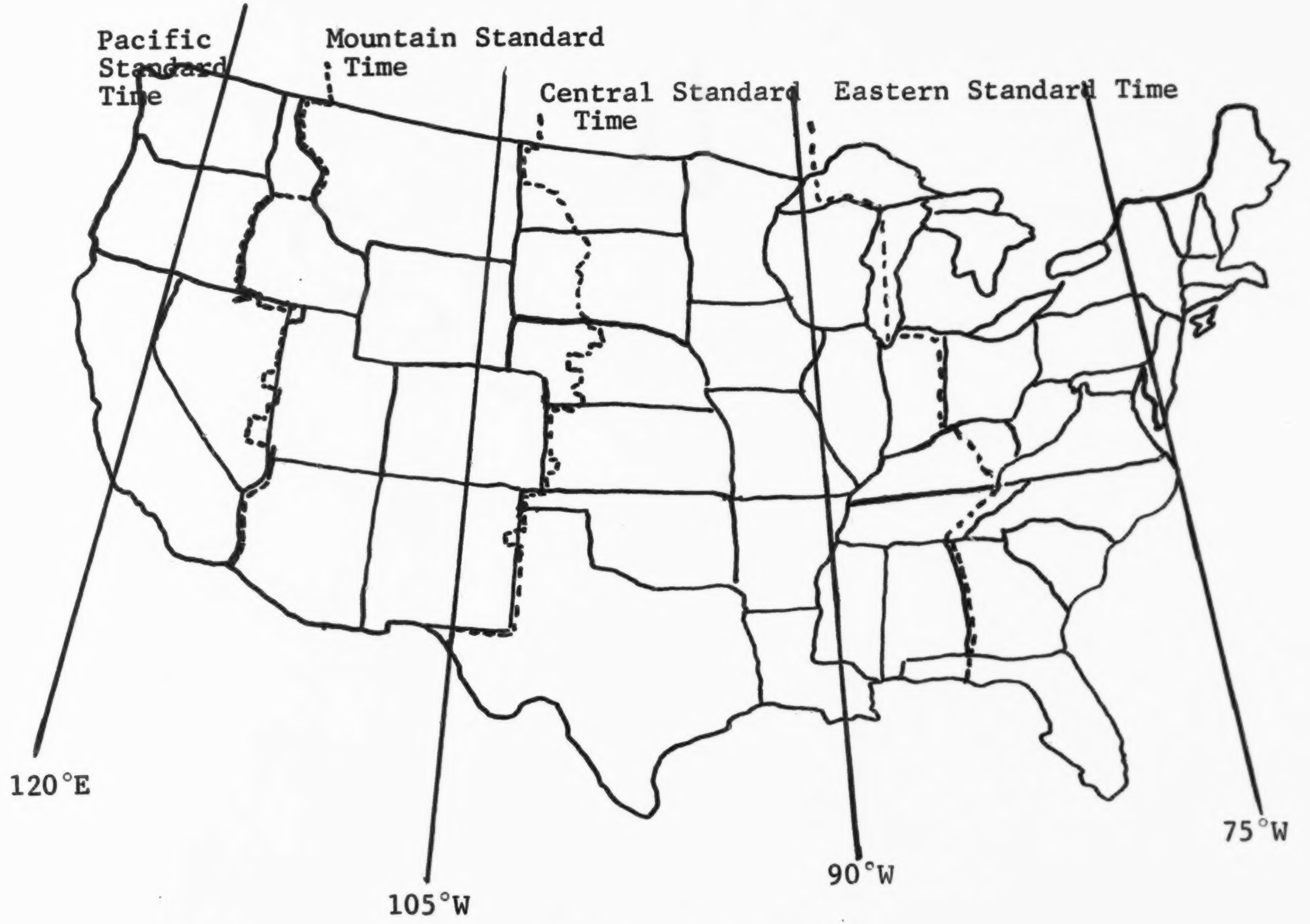
If the rotation of the earth were uniform, then the conventional sun would be a smooth running timepiece. The trouble is that the earth does not always travel with the same speed in its orbit around the sun. When the earth is nearest the sun (perihelion) then its speed is greatest, and when the earth is fartherest from the sun (aphelion) its speed is slowest. Thus a clock that keeps apparent solar time would run fast and slow depending upon where the earth is in its orbit.

To avoid problems caused by the changing speed of the earth, ordinary clocks are set to run uniformly and a 24 hour day is the average of the apparent solar days throughout a solar year. This kind of time is called mean solar time, and a year is 365 1/4 mean solar days.

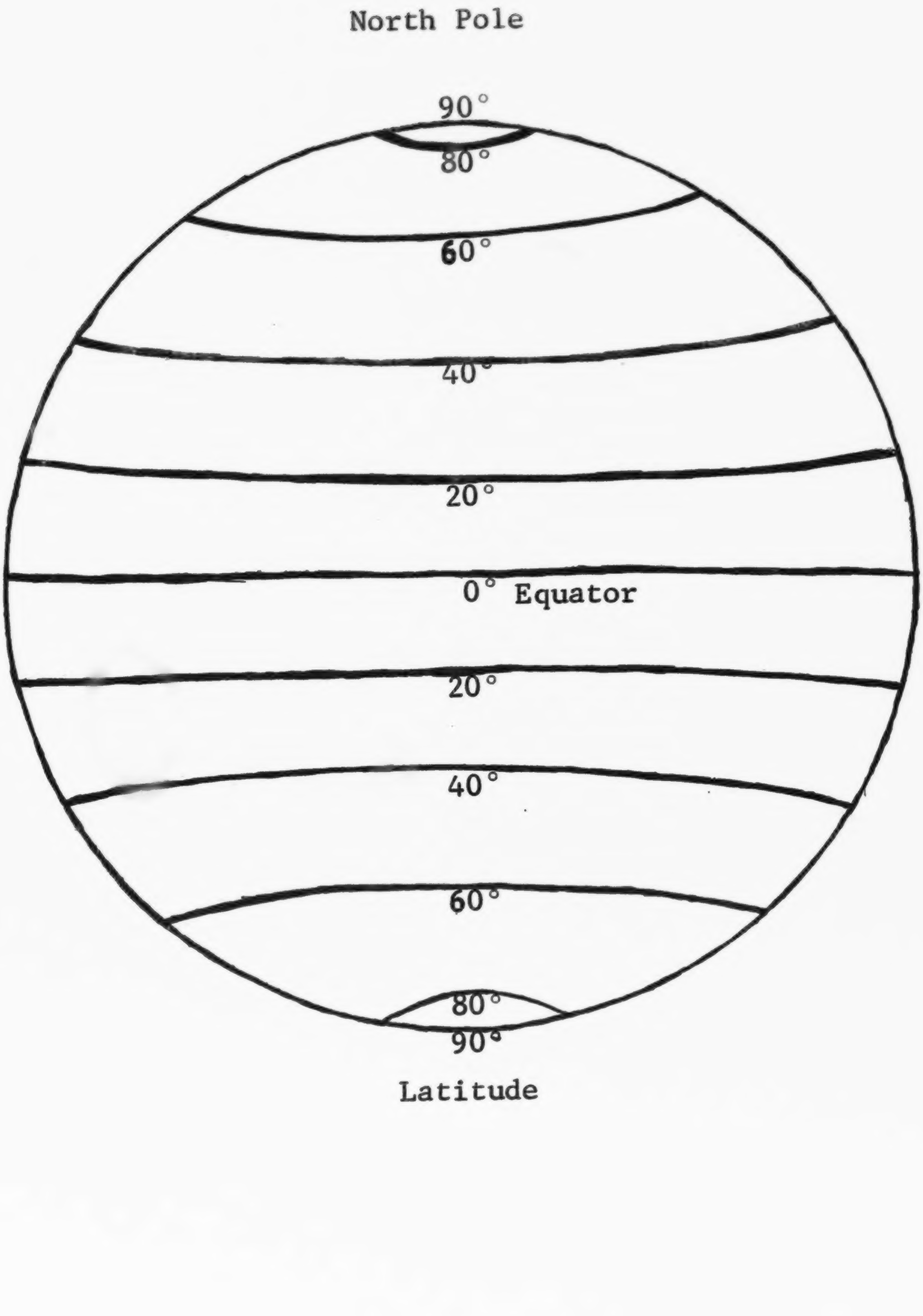
Since the mean sun apparently rises in the east and moves westward at a rate of 15° per hour, the times at a particular instant are the same only on the same meridian. The time is progressively earlier toward the west and later toward the east. In the early 1800's each town would set its clocks so that noon would come when the sun was most nearly directly overhead. One can imagine the confusion that ensued as a person traveled from place to place and each town had its own local time. This confusion was eliminated by establishing 24 standard time zones around the earth's surface. Starting at the prime meridian, zones 15° wide were set up with the central meridian being designated as the standard meridian. The standard time throughout the zone is the same as the local time at the standard meridian for that particular zone. The local time at the meridian of Greenwich was designated as Universal Time, and each zone differs from the adjacent zone on either side by one hour. The time is one hour earlier than it is in the zone immediately to the east, and one hour later than the time in the zone to the west. The rule to follow is on an eastward voyage set the watch ahead one hour when crossing a boundary between two zones; on a westward voyage set the watch back one hour. The minutes and seconds remain unchanged.

At sea the time zones are divided uniformly 7 1/2 degrees on either side of the standard meridian, but standard zones on land follow natural boundaries and state lines and are also affected by local preferences. These things make the boundaries somwhat irregular. To find the difference between the time in a given zone and Universal Time, one simply takes the longitude of the standard meridian and divides by 15. As an example suppose the longitude 75° west, then 75 divided by 15 = 5, so the zone time differs from Universal Time by 5 hours. If the longitude is west then the time is earlier than Universal Time and if the longitude is east then it is later. Again using as an example a longitude of 75° west, if Universal Time is 12 o'clock noon, then the zone time is 7 o'clock a.m. If the longitude were 75 °east, the time would be 5 o'clock p.m.

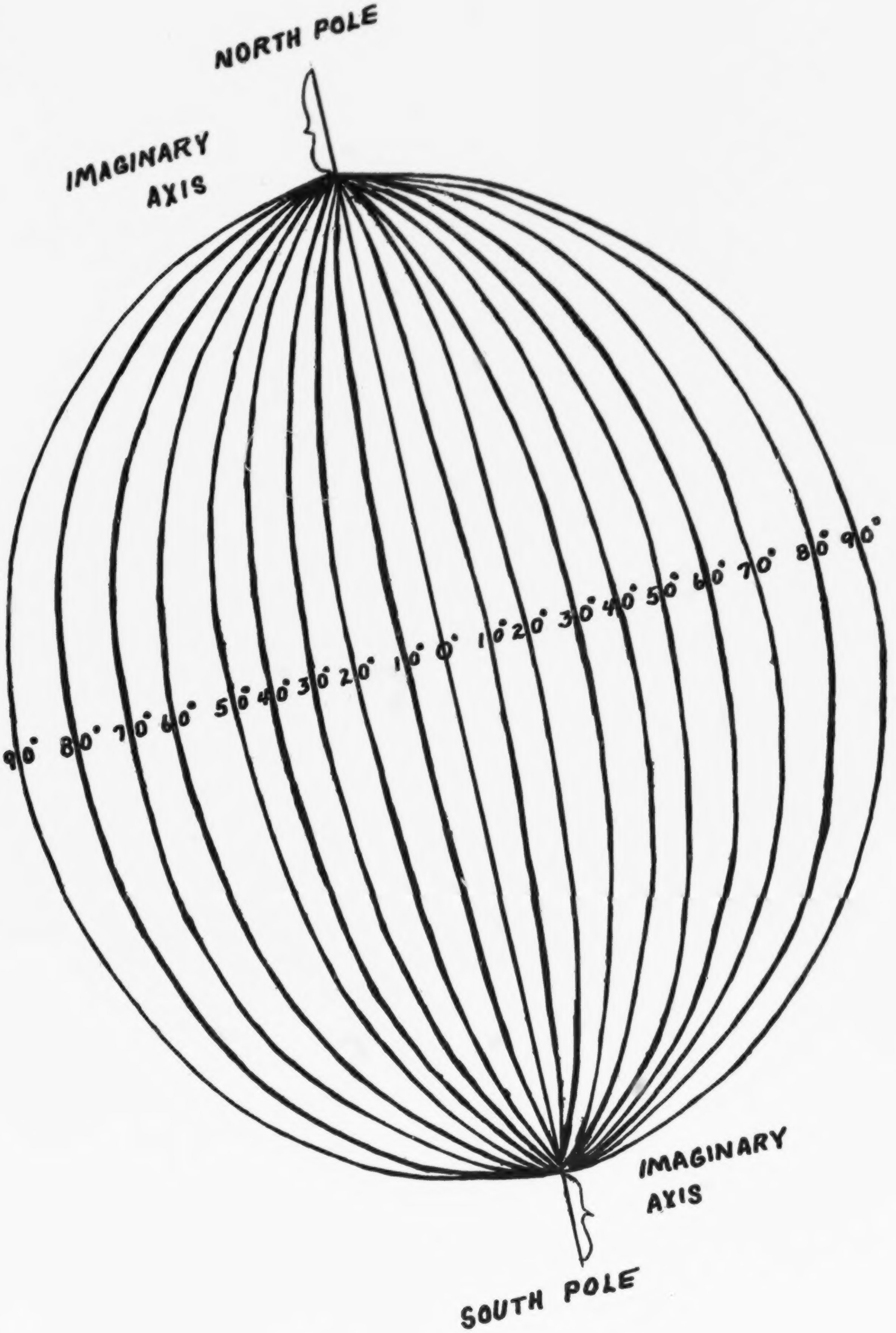
Four standard time zones are used in the United States, not including Alaska and Hawaii. They are the local civil times at the standard meridians of 75°, 90°, 105°, and 120° west of the prime meridian and they are called Eastern, Central, Mountain, and Pacific standard times. The following map indicates these zones.


Pacific Standard Time
Mountain Standard Time
Central Standard Time
Eastern Standard Time
120°E
105°W
90°W
75°W

Standard time Zones in
the United States.


North Pole
90°
80°
60°
40°
20°
0° Equator
20°
40°
60°
80°
90°

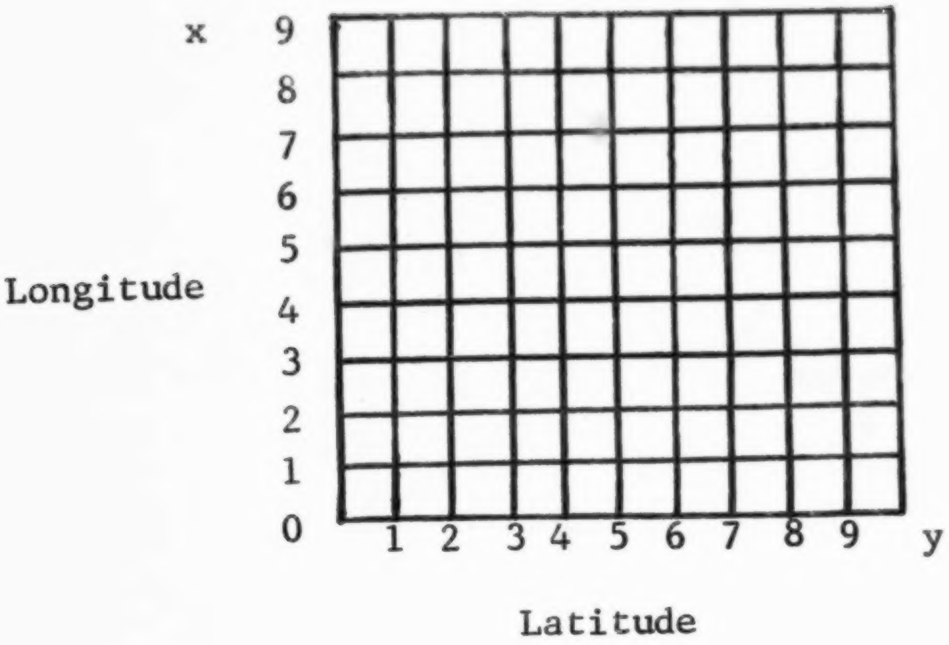
Latitude


NORTH POLE
IMAGINARY AXIS
90° 80° 70° 60° 50° 40° 30° 20° 10° 0° 10° 20° 30° 40° 50° 60° 70° 80° 90°
IMAGINARY AXIS
SOUTH POLE

Meridians of Longitude

F. Activities

(1)


x
9
8
7
6
5
4
3
2
1
0
Longitude
1 2 3 4 5 6 7 8 9
y
Latitude

Plot the following:

1. x 6, y 6
2. x 4, y 5
3. x 9, y 2
4. x 7, y 9
5. x 1, y 8

(2) Locate different towns on a road map.

(3) Where the longitude and latitude are given, the position of the place is clearly defined. For an example, the longitude of Yerkes Observatory at Williams Bay, Wisconsin, is 88° 33' W, and the latitude is 42° 34' N. Find this on a globe. Find the latitudinal and longitudinal position of your home town on the globe.

CHAPTER II

MAJOR STRUCTURAL UNITS OF THE EARTH

Objectives

1. How can I be certain that structures exist in the earth without seeing them?
2. Is there some way that I can calculate the strength of forces (such as gravity) that operates on this planet?
3. How is it possible to locate your position in the Pacific Ocean without radio contact?
4. Why does the geologist consider the earthquake as a method of investigating the earth's structure?
5. What sorts of forces do we find operating in the interior of the earth?
6. What observable phenomena increasingly cause men to question the permanency of major land masses?
7. What observable structures in nature help me to understand that mountains are being continuously formed and ended?

Have the major land masses of the earth always been structured and located as we see them today?

2.1 How can we investigate the structures that are hidden from our view?

A wide variety of methods are used by scientists to investigate the earth. In Chapter 1 you saw ways in which you can determine the mass, diameter and density. It is also evident that one can learn some things about the earth by examining samples of its materials. This is an important method, because it allows us to determine some properties such as chemical composition, temperature, mass, and density from first hand experiences. But this method cannot be used entirely. We must use indirect methods of study to investigate the interior of the earth and the high atmosphere. Since we cannot examine the material directly, we must obtain clues from gravity, magnetic, seismic and other studies. If we can relate the results of these indirect methods to things we know from direct experience, then we can draw definite conclusions that will be meaningful.

One indirect method of the investigation of physical quantities involves detecting and measuring the strength and direction of the various fields that are found in space. Definition of Field: A field is a region of space at every point of which a definite value exists for the quantity being measured.

Examples of fields that surround the earth and some of the other planets are gravitational fields and magnetic fields. We can use information gained from these fields to enable us to get a better picture of the shape of the earth and to investigate its interior.

A. Gravity Studies

Flip a coin upward and watch its speed decrease to zero and then fall back toward the earth. You are observing the earth's gravitational field at work. Why does water run downhill? In the mountains you often see signs saying, "Watch out for falling rock." A number of forces have been active in moving earth materials, but gravity is by far the most important.

Nearly everyone is familiar with the story of how young Isaac Newton was struck on the head by a falling apple one day. This incident led him to the discovery of the universal law of gravitation. Whether the story about the apple is true or not is incidental, but it is true that Newton discovered the law of gravitation at the young age of twenty-three.

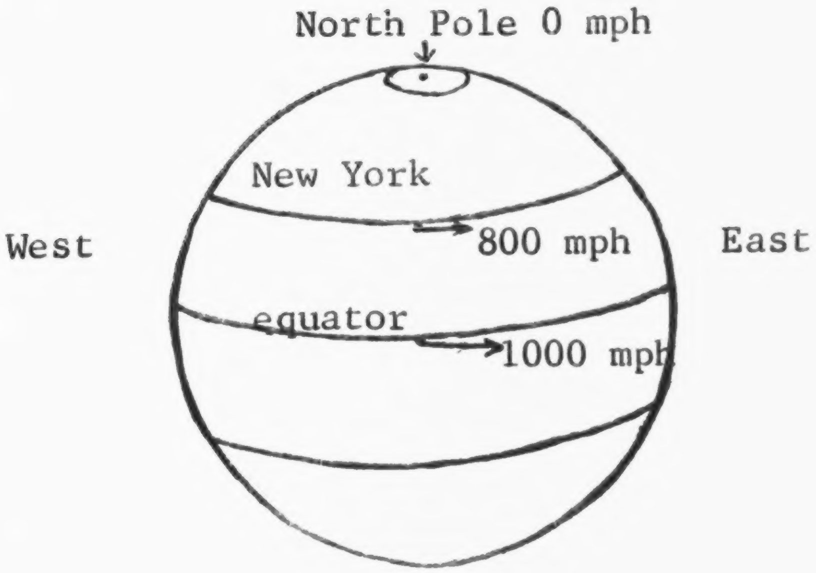
By the anlysis of the motion of the planets around the sun, Newton reasoned that each planet must have an attractive force on it. Furthermore, this force must be along a line joining the center of the planet to the center of the sun, and must decrease as the square of the distance between the planet and the sun. Finally he found that the force depends on the product of the masses of the sun and the planet. Newton next said that every particle of matter in the universe attracts every other particle with a force that obeys the same law. His next step was to go to the laboratory and try to experimentally verify this law and determine a constant relating the product of the masses of the bodies and the square their separation. Thus Newton formulated what is now known as the Universal Law of Gravitation, which can be stated as follows:

"Any two bodies in the universe attract each other with a force that is directly proportional to the product of the masses and inversely proportional to the square of the distance between the two bodies."

In mathematical symbols this law can be written as $F = \frac{G M_1 M_2}{R^2}$, where F is the gravitational force of attraction, G is called Newton's Universal Gravitational Constant and has a value of $6.66 \times 10^{-11} \frac{\text{meter}^3}{\text{Kg Sec}^2}$. M_1 and M_2 are the masses of the two bodies in kilograms, and R is the distance between the bodies in meters.

If we consider the earth to be one of the bodies, then the whole earth will attract each particle within the object according to the Universal Law. If we add up the forces with which each particle of the earth attracts the object, the results will be the total gravitational force of the earth on the object. A spring-type scale can be used to measure the force with which the earth pulls an object toward its interior. The attractive force between the earth and the object stretches the spring and the magnitude of the force can be read directly on a calibrated dial. The force thus measured is called the weight or the force of gravity on the object. If the earth were not rotating, then the force measured in this manner and the force calculated by the Universal Gravitational Law would be equal. The rotation of the earth makes the observed force of gravity less than the gravitational force.

To better understand the above statement, consider a man standing on a platform scale attached to the rotating earth; once every 24 hours the earth carries him around in a circle with its center on the axis of the earth. The size of the circle would depend on his latitude. It would be a maximum at the equator and decrease as he moves toward the poles. Since each part of the earth makes one complete rotation in 24 hours, it is obvious that the man's speed would depend upon his latitude. The diagram on the following page illustrates this point.



Velocity of points on the earth due to its rotation

Experiments show us that a force is required to make an object move in a circle, and if this force is not present then the object will fly off tangent to its curved path. Thus a part of the gravitational force is used to keep the man moving in a curved path, and the remaining part is what we measure on the scale. If the man could increase his speed so as to make one rotation around the earth in 90 minutes, then the entire gravitational force would be needed to keep him moving in a circular path and the scale would read zero. This is the condition often referred to as weightlessness. If the earth were to stop rotating, then the man's weight would be the earth's gravitational force.

We have represented in the above paragraph the two extreme cases. The earth is rotating and yet it takes 24 hours for one complete rotation which is much longer than the 90 minutes. Thus your weight is not zero, but it is less than the full force of gravitation.

Definition: Gravitational field intensity is defined as the gravitational force per unit mass. This can be calculated from Newton's Universal Gravitational Law.

$F = G\frac{M_E M}{R^2}$ but $M = 1$ unit mass, M_E is the mass of the earth, and R is the radius of the earth. Therefore

$$F = G\frac{M_E (1)}{R^2} = \frac{G M_E}{R^2}$$

The "acceleration of gravity" or the gravity field intensity can be found by placing a unit mass on a spring balance and measuring the gravity force on the unit mass. The gravitational field intensity is not the same as the gravity field intensity for the same reason that the gravitational force is not the same as the gravity force; namely the rotation of the earth.

One method of determining the gravity field intensity is by finding the acceleration of a freely falling body. This is not very practical except in the laboratory using special equipment. Another method is using a pendulum. The pendulum swings because of the force of gravity pulls on it. The greater the pull of gravity the shorter the period of the swing. Thus if we measure the length of the pendulum and the time for one complete swing, we can calculate the gravity field intensity.

To measure the gravity force directly, a precision instrument has been built. These instruments are called gravity meters and they work on the same principle as a spring balance except they are much more precise. A gravity meter measures the change in the intensity from point to point, but if one knows the value at any one point then the gravity meter can be calibrated so as to give the intensity at any other point.

The four most important factors influencing the value of gravity are:

1. Rotation of the earth
2. Shape of the earth (oblate spheroid)
3. Altitude above sea level
4. The density of the material between the position where the measurement is being made and the center of the earth.

Suppose a particular area shows an increase in gravity after corrections for the first three factors are made. This means that materials of higher than average density are present. In a like manner a decrease in gravity means deposits of materials of density lower than the average are present. Using gravity surveys, many salt and valuable ore deposits have been located.

Activities

1. Have the students calculate the gravitational field intensity using Newton's Universal Gravitational Law-- $F = G \frac{M_E M}{R^2}$ where M_E is the mass of the earth and R is the radius of the earth as found in Chapter 1.

2. Determine the gravity field intensity experimentally using a simple pendulum. Attach a fine string one meter (or one-half meter) long to a steel ball about one inch in diameter and suspend from a support to form a simple pendulum. Displace the bob about 15° from the vertical and release. Using a stop watch, find the time for the pendulum to make at least 25 complete swings. Divide the time by the number of swings to find the period (the time for one complete swing). Knowing the period one can find the gravity field intensity using the following equation.

$T \text{ (period)} = 2\pi\sqrt{\frac{L}{g}}$ or the gravity field intensity

$g = \frac{4\pi^2 L}{T^2}$ where L is the length of the pendulum.

B. Magnetic Studies

Magnetic phenomena have been known for centuries. Long ago it was found that a certain rock now called "lodestone" had properties of attracting soft iron and other pieces of the same mineral. The early Greek philosophers knew this, and there is evidence that the Chinese had a knowledge of this as far back as 121 A. D. It was also known that the attraction in lodestone is confined to certain regions called "poles." If a specimen is shaped in the form of a bar, the regions of attraction are apparently near the ends. But the poles are not separable. If magnet (a piece of lodestone shaped in the form of a bar) is cut in to instead of separating the poles, it is found that each piece becomes a full magnet with two poles.

By the early twelfth century the Chinese knew that when a small piece of soft iron was magnetized by rubbing it with lodestone, then mounting it free to turn, it would align its axis in a north-south direction. This seems to be the first evidence of a small magnet used as a compass. The reason that a compass needle, or small magnet, turns to a certain direction is due to the fact that a large magnetic field surrounds the earth, and the earth's magnetic field exerts a force on each pole of the magnet. The force on each pole is equal in magnitude but opposite in direction. Each force produces a torque and the combination of these two torques turns the magnet (compass needle) until it lines up in direction of the earth's field. The magnet usually is not exactly aligned with the earth's geographic north and south poles, but they point in that general direction. Because the same end always points in a northerly direction, we get the names "north-seeking" and "south-seeking" poles. These names have now been respectively shortened to simply "north" and "south" poles.

The force a magnetic field exerts on a magnet divided by the pole strength of the magnet is called the magnetic field intensity. Thus by definition a magnetic field is a region of space in which another magnet when placed in that space would experience a force, and the force per unit pole strength is defined as the magnetic field intensity. An experiment to aid in understanding the idea of a magnetic field is to take a thin glass plate and place over a bar magnet and sprinkle some iron filings on the plate. When the plate is gently tapped, the iron filings become concentrated near the poles and spread out in streamers as they move away from them. Actually the iron filings have become tiny magnets and are simply lining up in direction of the field of the bar magnet. This can be verified by the fact that a compass needle place anywhere in the field will line up along these streamers.

You have probably used a compass to determine geographic directions, and we have previously mentioned that a compass needle points in the general direction of geographic north and south. The compass needle actually points toward a point on the earth's surface called the earth's magnetic pole, and really has nothing to do with true north or south. The north and south geographic poles are points located on the earth's rotational axis, and are called true North or South. It happens that the geographic north pole and the magnetic north pole are in the same general vicinity. The coordinates of the north magnetic pole are approximately 73° north latitude, 100° west longitude. Because of the influence of large iron ore deposits near the earth's surface, a compass needle may even deviate considerably from magnetic north.

The angle between true north and the direction a compass needle points at any location is defined as the angle of declination. Suppose now the compass is turned so that the axis on which the needle is suspended would be horizontal instead of vertical. The needle would not come to rest in a horizontal position. Instead it would dip downward, showing the angle that the earth's field makes with the surface of the earth at the point in question. This angle is defined as the angle of dip. Therefore we can find the direction of the magnetic force by determining the declination and the dip. To determine the magnitude of the magnetic field intensity (size of the magnetic force on a unit pole) we use an instrument called a magnetometer.

By making a large number of measurements of the inclination, declination, and field intensity at different points on the surface of the earth, the magnetic field surrounding the earth has been mapped. The results indicate that the earth acts like a giant bar magnet with its magnetic field extending far out into space.

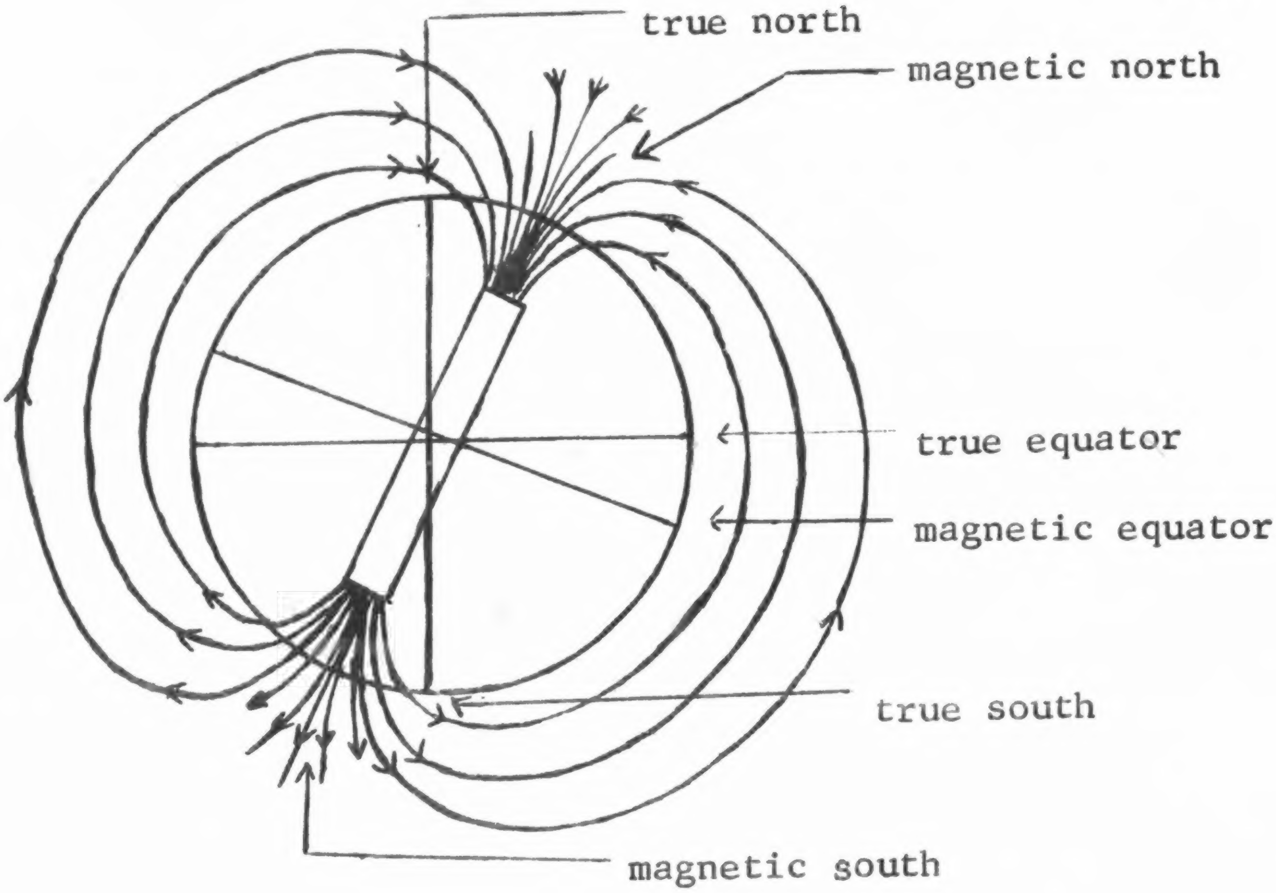

true north
magnetic north
true equator
magnetic equator
true south
magnetic south

Diagram illustrating the shape of the earth's magnetic field

The above diagram illustrates the general shape of the earth's field, but careful measurements show many variations in the field intensity. Since iron-bearing ore is highly magnetic, large deposits below the surface of the earth will cause variations that are easily detected. Using this method valuable deposits of ores have been found.

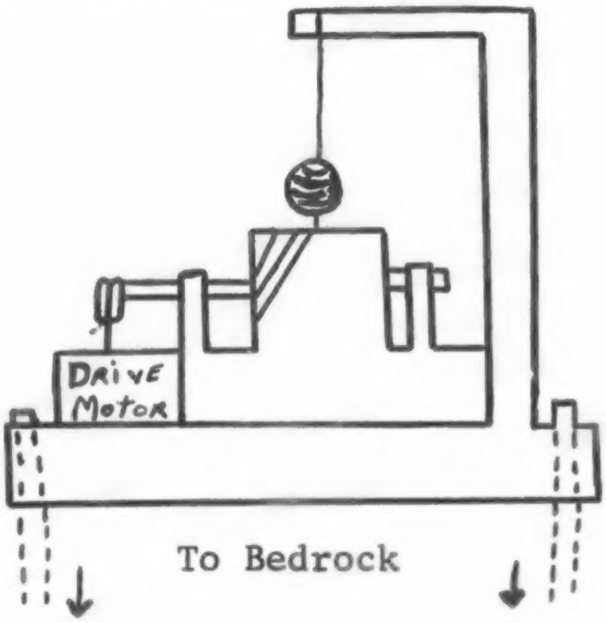
Activities

1. Have students place a thin piece of plate glass or a sheet of paper over a bar magnet, sprinkle on iron filings, tap the glass and observe the resultant field. Make a neat sketch of the field and compare with the earth's magnetic field.
2. Determine the angle of declination and the angle of dip at several points in and around school building.
3. Have students look up the meaning of the following terms:
    a. isogonic lines
    b. isoclinic lines
    c. agonic lines
4. Locate a magnetic map of the United States showing isogonic, isoclinic, and agonic lines.

C. Earthquake and Seismic Studies

The best method of investigating the interior of the earth is that of earthquake study. Most earthquakes are caused by the sudden slipping or shifting of the earth's crust. Normally rocks are strong and capable of withstanding considerable stresses, but if the stress becomes too great, the rock layer may split and slip apart causing what is known as a fault. Usually earthquakes originate within a few miles of the surface of the earth, and, associated with each earthquake are three quivers or waves. The first or primary wave is a longitudinal wave which travels at a speed of from 6 to 8 miles per second. This wave passes through the core of the earth as will be discussed later. The primary wave is followed several seconds later by a transverse or "shake" wave. The last quiver is a slow surface wave which generally travels in the surface rock. Most of the damage to buildings and to the surface of the earth is caused by this last quiver.

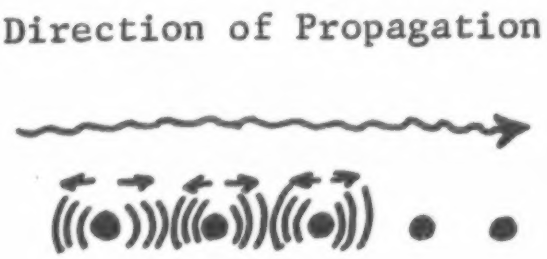
The "seismograph" is a valuable instrument that has been devised for the study of earthquakes. The earlier models consisted essentially of a heavy pendulum bob with a pointer in contact with a rotating cylinder. The base is firmly attached to bedrock and vibrates with the bedrock when an earthquake occurs. The pointer traces a straight line on the rotating cylinder until the bedrock is disturbed by an earthquake shock. When this occurs the base and cylinder are jarred and move before the pendulum can get into motion. Thus a sudden oscillation of the bedrock causes the pointer to draw a line at almost a right angle to the straight line. The severity of the shock will determine the length of this line.



Vibrations of short duration are produced by the primary and secondary waves of an earthquake, while the surface wave causes the pointer to execute a long vibration.

There are about 750 of these seismograph stations at different points around the world. Each of these stations keep 24 hour records when a shock wave is recorded. These records are sent to the Geodetic Survey Headquarters in Washington, D. C. and later to an international seismological center in England. By the accumulation of information from these records the center of any particular earthquake can be pin-pointed.

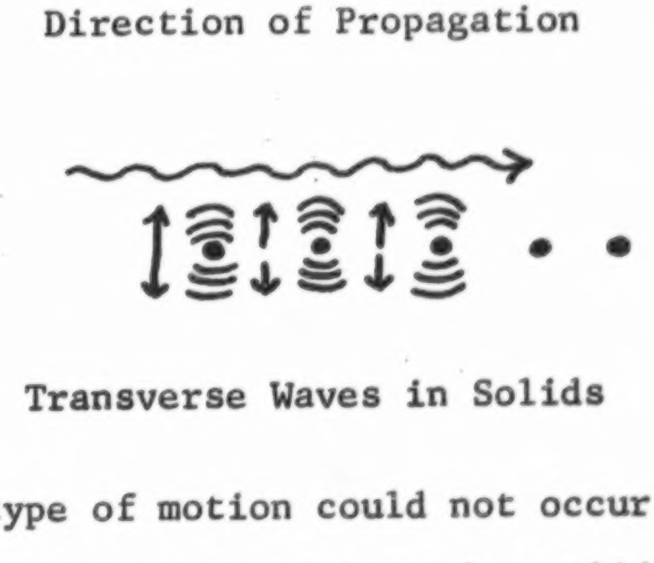
The interpretation of the earthquake record is done in terms of the principles of waves. Thus let us briefly consider the propagation of the fundamental types of waves. As previously mentioned the rocks in which the earthquake waves originate, and through which they travel, act like an elastic solid. Any elastic solid can vibrate two different ways. In one type of vibration of a solid the molecules vibrate back and forth in a direction parallel to the direction of propagation of the wave. These waves are called longitudinal waves and a good example is sound waves in air.



Longitudinal Waves in Solids

The speed or the velocity of propagation of a longitudinal wave depends upon the density of the medium and upon the elastic properties. In general the greater the density of the solid the higher the speed of the longitudinal wave.

There is, however, a second way in which a rigid solid can vibrate. The molecules or particles of the solid can vibrate back and forth in a direction at right angles to the direction of propagation of the wave. Vibrations of this type are called transverse vibrations.



Transverse Waves in Solids

This type of motion could not occur if it were not for the fact that the particles of a solid are bound with attractive forces by the neighboring particles. This attractive force has a tendency to hold the particles in an equilibrium position. Thus as particles move away from their equilibrium positions they are pulled back by these restoring forces, but once they overpass the equilibrium point they are then pulled in the opposite direction.

In the simplest terms, then, the restoring force on a particle is always toward the equilibrium point. As a result, the particles continue to vibrate at right angles to the direction of propagation of the wave. Transverse vibration can only occur in rigid solids, for only in solids are there restoring forces tending to pull the particles to their equilibrium positions. In liquids and gases the disturbance dies down because the displaced particles do not come back to an equilibrium point due to the lack of a restoring force. Like a longitudinal wave, the speed of a transverse wave depends upon the density and the elastic properties of the medium. These waves travel at a speed of about 4 miles per second in rocks near the surface of the earth.

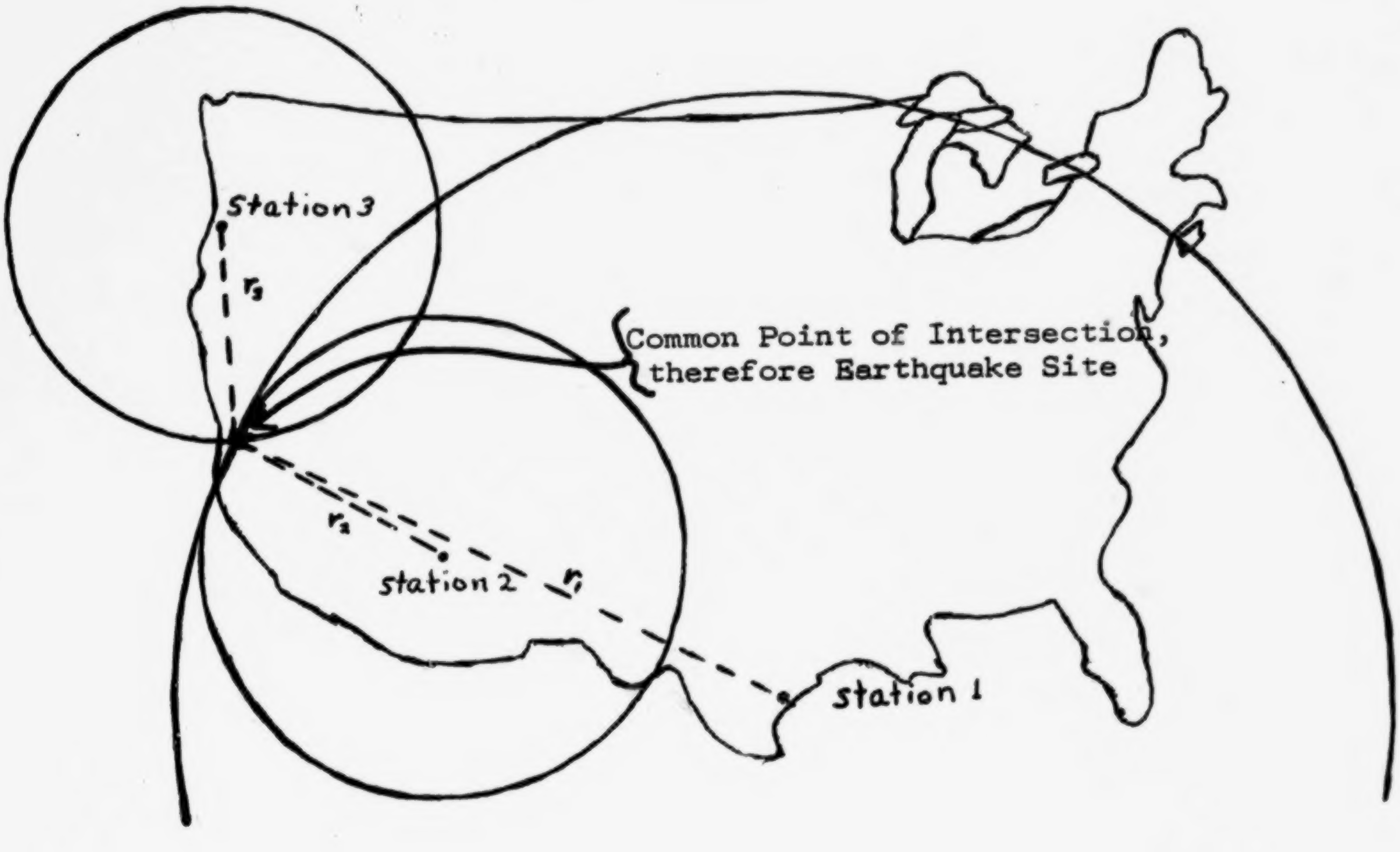
The slow surface wave previously mentioned can be considered a combination of both longitudinal and transverse vibrations. A combination of this type would produce circular or elliptical paths. These waves are similar to surface waves in water and on surface rock they travel with a speed of approximately 2 miles per second.

It is easy to see that by using the interval of time between the arrival of the primary wave and the secondary wave one can determine the distance from the station to the site of the earthquake. As an example, suppose the primary wave travels at a speed of 600 miles per second and the secondary wave travels at a speed of 400 miles per

6 neg.

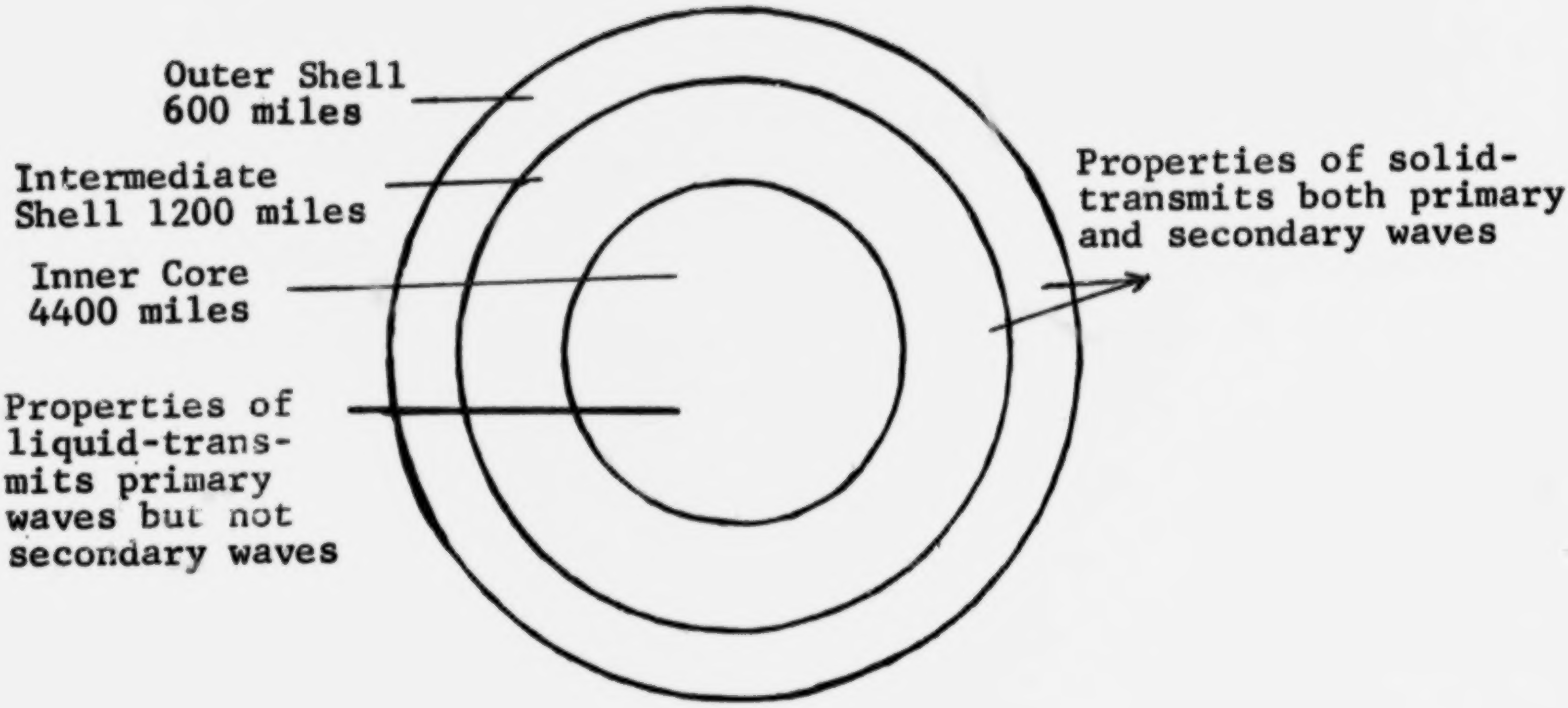
second, then if the interval of time between arrival of primary and secondary wave at a particular station is one second then the earthquake occurred at a distance of (600 miles/second - 400 miles/second) x one second = 200 miles away. If the interval of time had been two (2) seconds then the earthquake would have occurred 400 miles away, etc.

The exact location of an earthquake cannot be determined from the records of a single station, only the distance. Thus the earthquake site may be anywhere on the circumference of a circle at the determined distance from the station. However, if records from three stations are compared the exact site can be located. This is done by drawing on a globe three different circles, one from each station, with the determined distances as radii. These circles will have a common point of intersection and this point will be the site of the earthquake.



The diagram on the preceding page, although constructed on a flat place rather than on a globe, illustrates the fundamental principle involved in locating the site of an earthquake.

A more detailed study of seismograph records reveals information about the interior and the exterior structure of the earth. Considering the primary waves, one can follow the change in speed with depth and obtain a fair idea of the increase in density with increasing distance below the surface of the earth. These waves reveal that the earth consists of at least three shells of different material; the outer zone, the intermediate zone, and the inner core. An interesting fact about the inner core is revealed by analyzing records of the secondary waves. These waves go through the two outer zones. This is convincing evidence that down to 1800 miles the earth is a solid; since the secondary waves will not penetrate the inner core. Recalling that the secondary waves are transverse and can be transmitted only by a rigid solid, then the above information indicates that the inner core has the properties of a liquid.


Outer Shell
600 miles
Intermediate
Shell 1200 miles
Inner Core
4400 miles
Properties of
liquid-trans-
mits primary
waves but not
secondary waves
Properties of solid-
transmits both primary
and secondary waves

Structure of the Interior of the Earth

D. Heat Flow Studies

Heat flow studies are concerned with the way heat is transferred. This takes place in three ways: conduction, convection, and radiation. Heat can only be transferred if there is a difference in temperature between two objects, and then only in the direction of the lesser temperature.

Conduction of heat involves the transfer of heat from one molecule to another through impact. The conductivities of materials vary widely, and liquids and gases are very poor conductors of heat.

Convection is the transfer of heat by the mixing of the molecules from one fluid with another fluid subsequent to having gained or lost heat by contact with a hot or cold surface. A fluid may mix because of the differences in density resulting from the difference in temperature, or it may be forced to mix by mechanical means. Steam heating makes use of convection transfer.

All solid material, regardless of temperature, emits radiations in all directions. As the temperature increases the intensity of radiation increases. This can be proved by providing a light bulb with less voltage than it normally requires. The light will appear dim and as the voltage is increased the bulb will become brighter.

The transfer of heat by radiation is unique in that it needs no conducting substance. This unique property makes it possible to transfer large amounts of heat from the sun to the earth.

2.2 What can studies to date tell me about the interior of the earth?

Objectives

1. How have scientists been able to approximate the composition of the earth?
2. What is the composition of the core?
3. What is the accepted hypothesis of the depth of the mantle?
4. In what state of matter are the core and the mantle?
5. What is the estimated temperature of the mantle and the core?
6. What types of rocks make the crust of the earth?

The rigid shell that makes up the crust is the thinnest layer of the earth. At any place on earth below us lies the rocky crust which is bedrock, the solid stone we see exposed in hillsides, quarries, and road cuts. This bedrock is essentially of three types. First is igneous rock that is formed from molten material originating far beneath the earth's surface. Many times this molten material or magma cools under the layers of rock beneath the surface of the earth forming intrusive igneous rocks. When magma flows out on the surface from a volcano or from a crack in the earth's crust extrusive igneous rocks are formed.

The second type is sedimentary rock which is formed in layers from materials deposited by water, wind, ice, chemical changes, and the activities of living things. Some examples of these are sandstone, shale, limestone, and salt. The third type is metamorphic rock which may be both igneous and sedimentary rocks that have been changed from their original form by great heat and pressure, or by liquids or gases percolating through them. Marble, gneiss, and schist are examples of this type.

Bedrocks were not created once and for all. The conditions that made the rocks as we see them today are making the rocks of tomorrow. New igneous rocks are being made from molten material, and sedimentary rocks are being formed wherever sediments of clay and sand are being packed by the weight of materials from above. These in turn are being converted into metamorphic rocks. These three processes are producing new supplies of minerals for earth's unique stock.

Most of man's explorations of the interior of the earth must be confined to laboratories since he is unable to go far into the earth. Much information about the inside of the earth is obtained from observing how different materials behave under great pressure and high temperature and by observing how earthquakes' waves act as they pass or do not pass through different parts of the earth.

Much has been learned about the interior of the earth by studying earthquake waves. There are two main groups of these waves, the body waves and surface waves. The body waves go through the earth and the long waves travel around the earth below the surface. Earthquake waves indicate that the inside of the earth is not the same all the way through, but that there are three distinct layers. (1) The crust is light rock with a depth of 10 to 20 miles. (2) The mantle extends to a depth of 1800 miles. (3) The core seems to be divided into two layers; the outer core, extending to a depth of 1800 to 3100 miles, and the inner core, which reaches from 3100 miles to the center of the earth.

The mantle is believed to be made of a dark colored igneous rock, heavier than granite and rich in iron ore, but until it becomes possible to drill holes into the body of the earth no one can know what lies within the interior. The hypothesis is that the mantle is composed of rocks with a density several times greater than the average density of the rocks in the crust.

It is believed that the outer core is composed largely of iron or nickel in a hot plastic or liquid state. There is evidence which indicates that the outer core is about twice as dense as the material which makes up the mantle.

The inner core is thought to be largely iron and nickel, similar to the outer core, but since the pressure is near 60,000,000 pounds per square inch, it is in a solid state.

Temperatures at great depths have been estimated from the knowledge of the density of mantle and core. These estimates indicate that the temperature of the mantle is not greater than 4000° F. and the core probably not much hotter than 10,000° F.

At the present time there is not enough information on the core and the mantle to accurately describe them, but scientists keep planning to drill a hole into the ocean floor that could yield valuable information about the history of the earth and the composition of its interior.

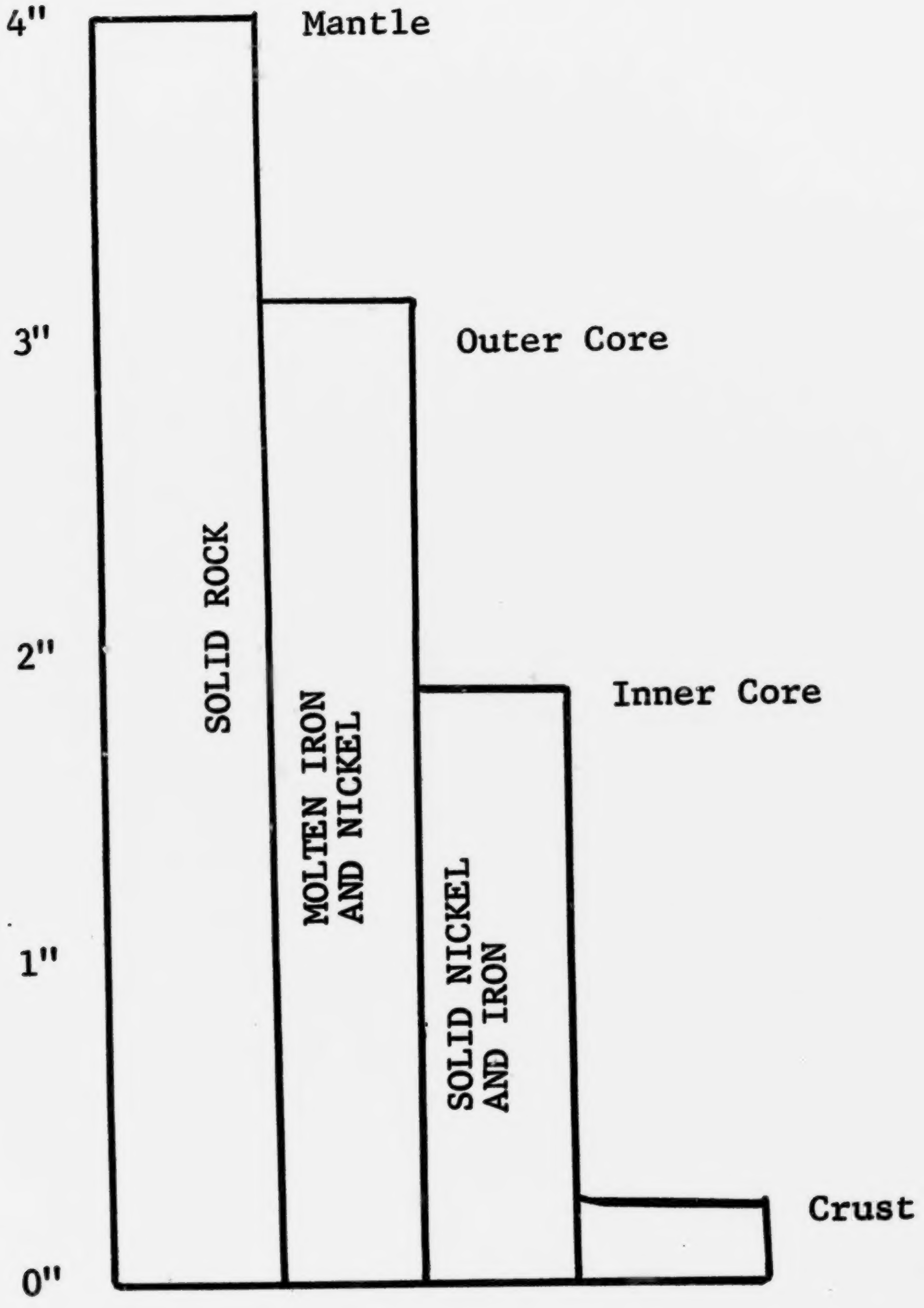
EVALUATION

1. Do students have a clearer conception of the composition of the earth's interior?
2. Did the students understand the principles of earthquake waves?
3. Was it a challenge to the students to find out more about the interior of the earth?
4. Does the unit lead to functional understanding of the earth's interior?
5. Were all the objectives developed?

Activities

1. Boil an egg until the yolk is hard. While the shell is still on, cut the egg into equal halves. Explain that the shell is the crust, the white represents the mantle, and the yolk represents the core.
2. To give children a general idea of vibrations or waves, let them hold a table fork lightly by the handle and strike the other end sharply against some object. Vibrations may be felt in the handle where it is held. Gently strike objects made of other materials. Are vibrations felt or heard? Are the vibrations the same? Sounds are made by waves or vibrations. Earthquake waves are earth waves or vibrations which change their speed and the way they behave as they come in contact with different earth materials.
3. What is the structure of our earth?
    1. What is the depth (in mileage) of the earth's mantle?
    2. What is the thickness of earth's outer core?
    3. How deep is the earth's inner core?
    4. About how many miles is it from earth's crust to earth's inner core?
    5. About how thick is earth's crust?

Use the graph on the following page to answer the above questions.


4"
3"
2"
1"
0"
Mantle
SOLID ROCK
Outer Core
MOLTEN IRON AND NICKEL
Inner Core
SOLID NICKEL AND IRON
Crust

2.3 What observable phenomenon today makes me question the permanency of the major land masses?

A. Theories supporting permanency such as:
   1. No deep-water sediments on land
   2. Ocean basin capacity

Purpose: To establish an idea of constancy of large land formations of earth.

The student who has pondered the permanency of his world may have questioned the permanency of the continent on which he lives. He may have noticed the erosion of river banks, or watched the tremendous wearing of the coastline and asked if the land where he lives may have been, or may someday be under water.

The inquiring student may have reasoned that the ocean basins can only hold a certain amount of water and that an imbalance in the amount might flood his homeland. Because of the particular structure of the earth's surface, there are areas of crust with much greater elevation than others--these areas are continents, islands and continental shelves. A study of a globe may make it obvious that were these elevated areas to be leveled, water would cover the entire earth.

We know that if all the ice were melted and all the continents leveled, the earth's waters would cover the surface with a layer hundreds of feet deep. If all the ice of Antarctica alone melted, the water level of the world's oceans would be raised over 200 feet. What then may we use as a reference for the constancy of our "dry" home?

Of some consolation is the human knowledge that no mechanism is known whereby continents or oceans can be moved. No known force is great enough to move even a large island, much less an entire continent.

Thoeories of the continents drifting apart from a common beginning have been proposed for several decades. If this were true, the Atlantic and Indian Oceans should be older than the Pacific. There is no known difference in the ages of the oceans.

Although geologists are constantly discovering new things about our earth's surface, they have yet to discover deep-water sediments on dry land. We are also encouraged to find that no continental rocks are found in the true oceans. These two facts give the impression that our continents are, and have always been permanent.

Activities

1. Review concepts of radiocarbon dating.
2. Studies of the theories held by Mohole Project.
3. Take a field trip to try to discover fossils which might indicate your area may have been underwater.

EVALUATION

1. What would happen if all the earth's ice fields were to melt?
2. How would one proceed to move a continent?
3. What evidence do we have that the continents have not been a part of the oceans?

B. Theories supporting continental drift such as:

   1. Climatic evidence
   2. Glacial evidence
   3. Paleomagnetic surveys
   4. Structural fit
   5. Parallel life form development
   6. Basaltic floating
   7. Theory of ocean floor renewal

Purpose: To explain the possibility of constant movement of the large land masses of earth.

1. Climatic evidence

The effects of movement of the solid parts of the earth (diastrophism) may be seen in various ways at the earth's surface. Erosional features such as the position of stream valleys, and the uplifted shorelines are evidence of movement. By studying the magnetism of rocks, scientists have found evidence that the poles and the continents have changed their relative position. By examining magnetic samples from different geologic ages, geologists believe that the movement has taken place since the late Mesozoic Era.

Much evidence to support diastrophism is based on the reconstruction of the climates of the past. Our climatic belts of today are arranged in roughly parallel zones from the tropical climates at the equator, to polar ice climates. If we assume that basic climatic controls have remained the same, then we must further assume that the climatic belts have always paralleled the equator even though they might have been both colder and warmer than the present.

Geologists have been able to map in a general way the distribution of ancient climates and climatic zones. A comparison suggests that the poles and equator related to these ancient climatic zones are different from those of today. This would indicate that the land masses and poles have varied relative to each other since those climates existed.

The mantle is where geophysicists find clues on terrestrial magnetism which could explain shifts in the earth's magnetic field. It may also provide biological evidence to support continental drift.

An ice age of 200 million years ago spread a glacier over the Northern Hemisphere even as far north as the Arctic Circle. England may have been very near the equator and geological evidence indicates that India may have been much farther south.

Findings since 1955 in Antarctica show evidence of a tropical age when a low grade deposit of coal was laid down and also of an ice age which influenced the other lands of the Southern Hemisphere.

The Big Leafed Glossopteris flora have been found in Antarctica.

Many scientists believe that the parallel development of both animal and vegetable life on the continents could not have been mere coincidence, but must be explained either through land bridges or a single beginning on one large continent.

Because land bridges have been discredited in large by the chemistry and density of continents and the ocean floor, the migration of continents may be a more likely explanation of biological evidence.

Activities

1. Make a series of maps showing corresponding glacial ages of American and European continents.
2. Discussion of factors of change necessary to create simultaneously the evolutionary steps on separate continents.
3. Study basic periods of geological history and try to locate development of types of plants or animals.

EVALUATION

1. Is there a possibility that the climates of our continent may have changed?
2. What would cause our climate to change?
3. How would a change in climate affect the life we now know?

2. Glacial Evidence

Purpose: To provide verification, or disproof of continental drift theory by parallel studies of the major glacial periods of the Americas and Eurasia.

A glacier may be defined as a mass of snow that has gradually accumulated and been compressed into ice. On the surface the snow is soft, but underneath it has become much harder because the great weight alone has caused it to become packed. Near the bottom, pressure has turned the snow into hard pellets and solid masses of ice.

Pressure causes some of the ice on the bottom of a glacier to melt, and when this happens the whole mass begins to move slowly. Geologists have studied the movement of glaciers, and from their observations they have learned that some small glaciers may move only a few inches a day while others may move as rapidly as 100 feet a day. They also observed that they move more rapidly in the center than at the sides where friction with the walls of the valley hold them back, and they move faster after heavy snowfalls, on steep slopes, and in the summer.

As a glacier moves downhill it gouges the bedrock in its path with boulders and rocks that are imbedded in its bottom, and simply bulldozes the soil and anything else that may be in its path. Through the years this action may dig out huge areas of earth. It wears off the rock over which it passes in the same manner that sandpaper wears away the surface of wood.

As a glacier reaches a part of the earth where the temperature is warm, the ice melts and the materials carried by them are deposited in formations called moraines. If a glacier melts and drops its material in the same place for a long period of time, a terminal moraine is formed. Examples of moraine deposits are found along the east side of the mountains in Rocky Mountain National Park in Colorado, and the hilly land of Northern Long Island in New York.

The surface of the earth has been changed in many ways by glaciers. Most school children are aware that the Great Lakes and many smaller lakes in Minnesota and Wisconsin were formed by the action of glaciers.

Even though 5 percent of the country of Switzerland is covered with glaciers today, they are a major reason for its being habitable at all. It is believed that at one time Switzerland was a country of bare rock peaks divided by narrow canyons. Four successive glacial sheets ground through these canyons, slowly widening and deepening them. Finally the rounded valleys as we know them today were formed. As the ice retreated it left some of the soil behind. Today the melting glaciers water the soil of the valleys making it possible for grass to grow for the cattle and goats of the Swiss herdsmen.

The Greenland glacier is all that remains today of the vast ice sheet that once covered all of Canada and the northern part of the United States during the Great Ice Age. The glaciers of this age brought large amounts of soil from the north and left it on what is now the United States. When they melted, they left behind large moraines with huge boulders in them. These boulders cannot be carried for long distances except by moving ice.

Activities

1. To show that rocks can be broken by being struck or rubbed by other rocks, take two rocks and rub one against the other. By rubbing one rock against the other, you can make the two rocks smooth. Rub the rocks over a sheet of white paper and notice the particles which rubbed off.

3. Paleomagnetism

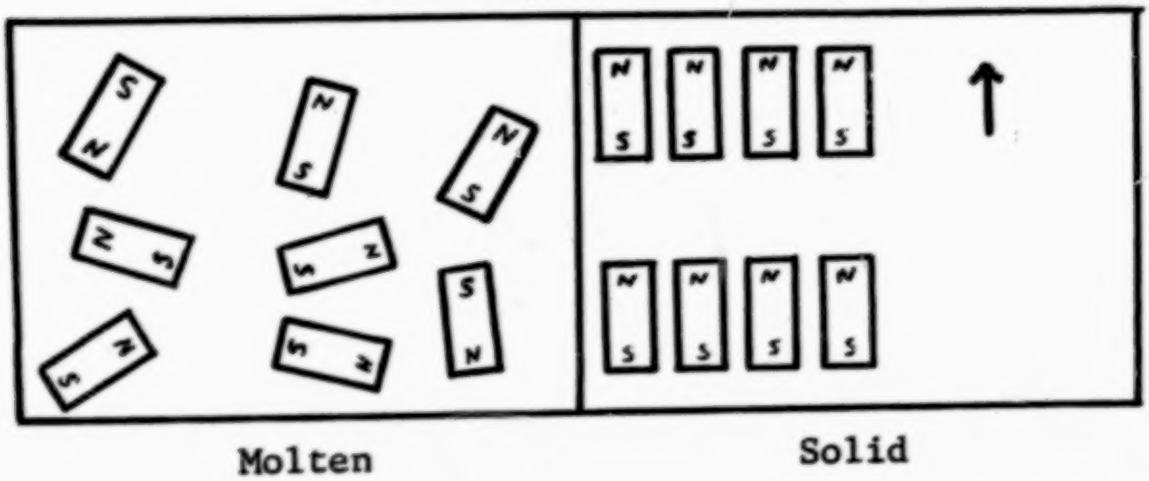
Purpose: To explain how recent studies have shown discrepancies in the magnetic alignment of materials of the earth's surface.

Some of the basic rocks of earth, particularly hematite, or magnetite, are strongly magnetic. Within sedimentary of igneous rocks magnetic particles, when examined, are found to align themselves along a north-south axis. This magnetic property forms the basis for paleomagnetism or a study of the earth's magnetic field in the geologic past, because these tiny compass needles do not lose their magnetism. In rocks known to be millions of years old, the little grains are still present with their magnetism unchanged. Even those grains which have been eroded, washed or blown across the earth retain their magnetic properties.

Recently, studies of continental magnetic fossils indicate that the latitudes of continents have been changing throughout much of the earth's history. For example, rocks formed in the British Isles over 200 million years ago show that England was much closer to the equator at one time. Other fossils indicated that the India subcontinent may have been much farther south than it is today.

Rock formations of both igneous and sedimentary rock have been found to contain grains of magnetic material. Such rock formations are found in North American, Great Britain, and Australia and indicate that the magnetic poles have wandered far and wide through the ages. Apparently the north magnetic pole has been located in such unlikely places as the North Pacific Ocean, Korea, and Arizona. At times, we actually believe the north and south poles have exchanged places.

Paleomagnetic Rock



(Bar magnets represent the iron grains)

Experiences:

1. Field trip to find natural magnetic rock.
2. Unit on compasses and magnets.
3. Discussion of differences between geographic North and magnetic South. (Magnetic declination)
4. Experiment:

Purpose: to show magnetic alignment of a magnetized iron bar.

Method: suspend an iron bar with string from a stand. Observe the movement of the bar.

Evaluation:

1. What is paleomagnetism?
2. Where can we find evidences of paleomagnetism in the United States?

4. Structural Fit:

Purpose: To show how the continents may have been a part of the continental ridge by fitting the marginal edges together.

a. Alignment of continental ridge with American and European Continents

(1) The first coherent theory concerning the position of the continents as they are today is that on continental drift. In 1912 Alfred Wegener, a German meteorologist, proposed the idea that the continents were a single, vast continent that he named Pangaea (from the Greek for "all" and "earth"). This primeval continent, he argued, broke up and drifted apart toward the end of the Mesozoic Era. The early evidence for the theory was drawn almost entirely from geologic records, but he also supported his theory by many observable facts, such as the way the continents would fit together.

Supporters of this theory use maps of the world to show how neatly South American and African fit together. They also used Europe and North American, but the fit is not too good at sea level.

(2) Computer evaluation of configurations of continental ridge (as a result of sonar records) in comparison with continental configurations have shown that the continents may fit best along the ridge. These newer theories may be further substantiated by new geophysical techniques including:

(a) Aerial studies of magnetism

(b) Sonar

(c) Mohole project of core extraction.

Activities

Materials needed: World Map, scissors

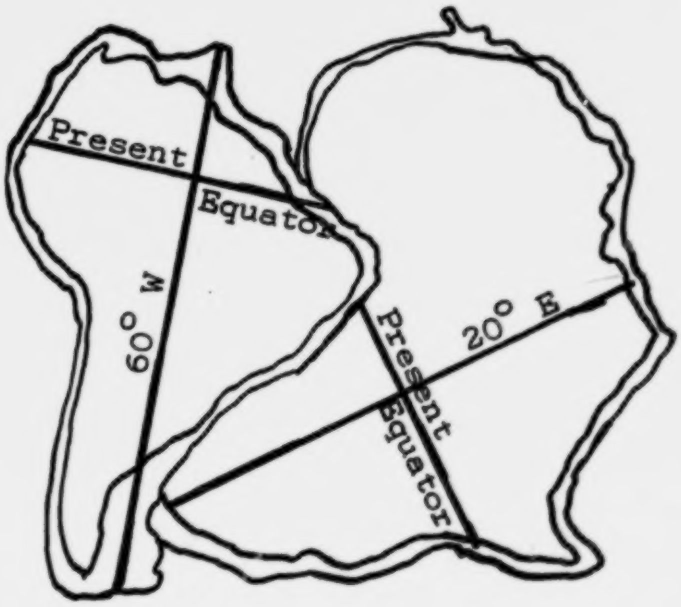
Procedures:

1. Show how northward movement of Africa could have formed the Alps.
2. Show how westward movements of North and South America could have formed the western mountain ranges of the continents.
3. Show how North and South America would fit against Europe and Africa if they were moved eastward.

4. Show how mountain ranges of different continents would match.
5. Show how continental edges would match against continental ridge.

CONTINENTAL DRIFT

Suggested Activity: Cut out two continents to see if they will fit.

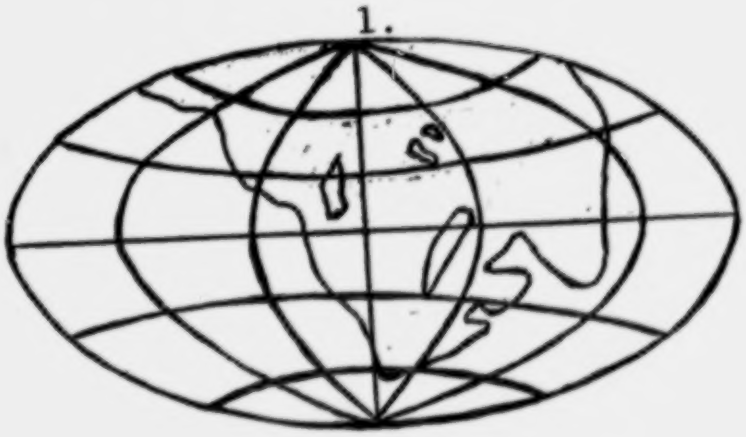


South America and Africa fit very closely together, particularly if the match is made at a level 2,000 meters (6,500 feet) below sea level.

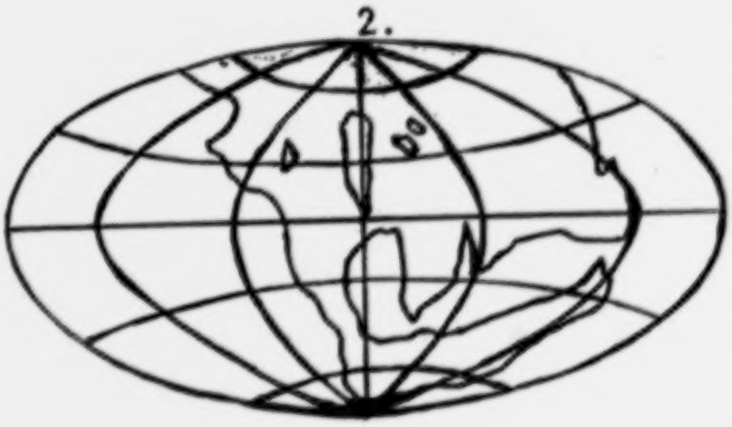
Redrawn from S. Warren Carey, "The Tectonic Approach to Continental Drift," in Continental Drift, a Symposium.

Three Stages in Formation of Continents from Original Land Mass

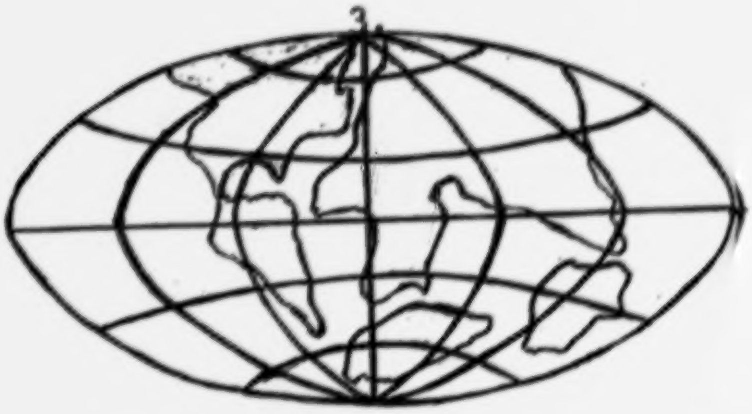
1.



2.



3.



Diagrams from:
The Story of Geology,
pp. 156-157.

EVALUATION

1. Why did Wegener believe the continents were originally one large body?
2. How have scientific instruments improved on the original theory?
3. What might the earth be like if the continents had never separated?

6. Basaltic Floating
7. Theory of Ocean Floor Renewal

Purpose: To give an explanation of how continents might be moved and what might cause this movement to occur.

In considering the theory of continental drift, two general types of movements may be involved:

a. Movement of the continents relative to one another
b. Movement of the earth's poles

The magnetic and rotational poles remain fixed within the earth, but if the crust moves, then different points would be at the polar position at different times.

There are different theories about how this movement may take place. Among these are basaltic movement and ocean floor renewal. These are related and can best be explained in relation to one another.

Beneath the crust of earth is the mantle, which is a shell of rock over 1800 miles in diameter. The mantle appears to be hard, perhaps due to the tremendous pressure, but should a stress occur, the mantle rock will yield to twisting, bending or perhaps even to flow... like bread dough.

There is a layer called the asthenosphere below the earth's crust which seismic observations have shown is less dense and more viscous than the other layers. Thus thermal convection currents could cause motion and the very plastic layer would provide a media on which the motion may occur.

It is comparatively easy to understand that when the surface rocks of the earth are broken by stress and pulled apart, the gap is filled by the altered top of the mantle and by flow of basalt lavas. With this theory we can see that the continents would be passively moved by the lateral movement of the crust from where the convection currents begin, to where they sink. The large land masses being built by accumulation of siliceous or lighter materials are not sucked down into the trenches, but are piled up as mountains where currents sink. But the altered mantle of the ocean floor is dragged downward as sediments in the descending trenches, and may add new mountains to the continents.

Continental migration could be explained by a shift of land masses in relation to each other. The course taken in polar migration also suggests a general drift of continents apart from each other and in some cases, there is an additional rotation of the continents.

It is claimed, for example, that northward movement of Africa created pressure against Europe, forming the Alps and neighboring mountains, and that the Western mountain ranges of North and South America are the results of "piling up" as the continents drifted westward against the basalt of the Pacific.

This idea of the splitting continents has been substantiated through dating of ocean sediments through new drilling methods. Samples have shown differences in the ages of deposits on the ocean floors. They have indicated that the older sediments are nearest the continents. Also, scientists have discovered that an area of "recently" (geologically speaking) deposited sediment lies nearest the continental ridges.

Small land masses (which may give a clue to larger masses) are known to shift in relation to one another. The San Andreas fault in California is an example.

Studies of the earth's magnetic field off the Coast of California have shown a pattern of anomalies in the ocean floor. The pattern is similar to that recorded in plastics under stress by polarized light. They are apparently inactive fractures of considerable age. The ocean floor is faulted at right angles to the axis of the ridge and great slabs of crust can be found displaced as much as 750 miles laterally to the west.

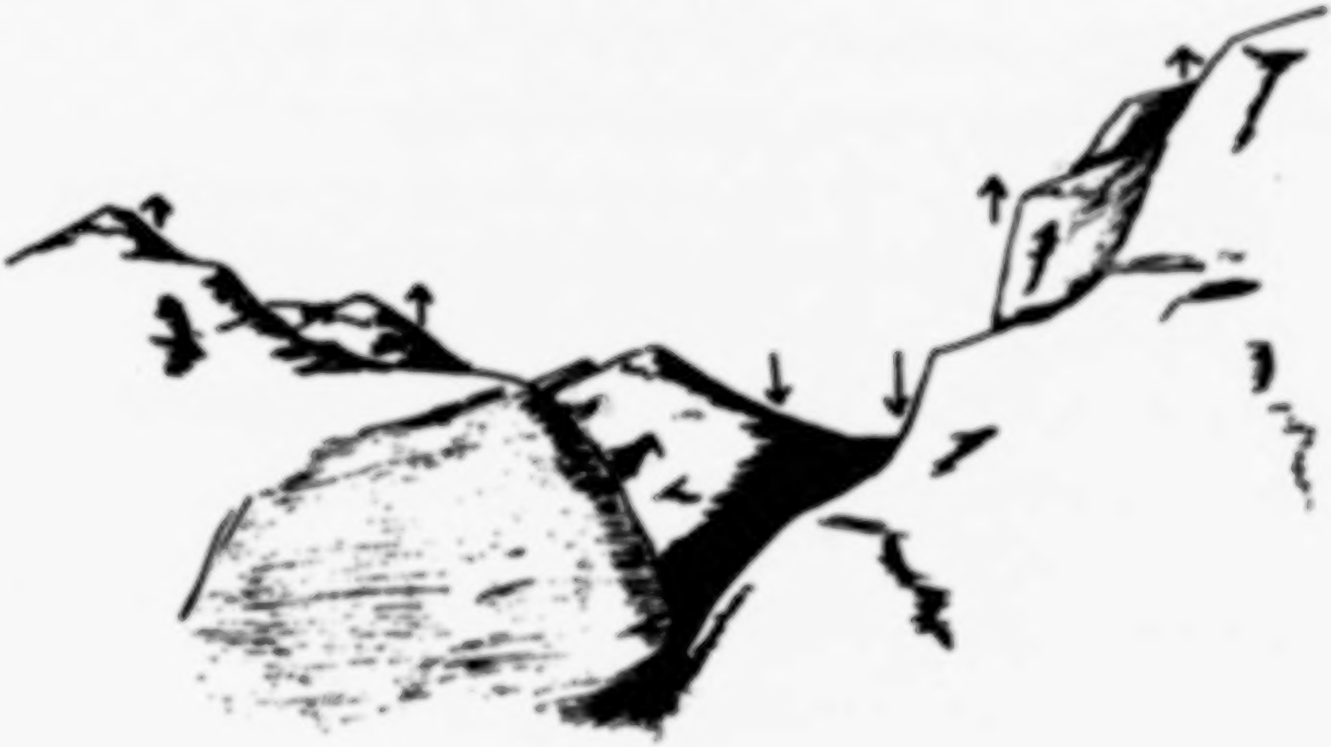
Recent investigations lead scientists to think that Africa and Asia may be in the process of splitting apart. In the island of the Red Sea, out-croppings of rock are found that may have been pushed up by a rift in the crust. These may be from the mantle of the earth.

Over the deepest trenches of the ocean floors are some of the greatest lacks (or deficiencies) of gravity ever recorded... and yet some unknown force pulls the crust into the deep trenches with a force greater than that of gravity. We now believe this is due to the thinness of the crust under the trenches rather than to a downfolding of granitic rock. At one time people believed that the earth was constantly moving inside. They thought this might be due to a slow thermal convection. No one knows for sure that these convection currents exist, but there are several reasons for believing that they do. These include:

a. The earth's recoil after glaciers is one evidence that the earth's mantle is viscous...to stop convection the earth's mantle would have to be 10,000 times more viscous than it is.

b. Recently scientists have discovered where these currents seem to rise against the surface of the earth. This is along the great system of ridges.

Measurements have shown that along the ridges the flow of heat is unusually great, (maybe 2 to 8 times greater than the flow of heat on the continents or on the ocean floor) but the flow of heat in the trenches is about 1/10 of average. Thus the ridges may be where heat is coming out of the ocean and the trenches where the colder currents are descending.



Suggested Activities

Experiment # 1

Purpose: Shows how lighter substances react when suspended in water.

Material Needed:

1. Large beaker
2. Water
3. Several tablespoons shortening

Procedure: Float the shortening in the beaker of H_2O, or pour water in a bowl and float it there.

Experiment # 2

Purpose: Observe buoyancy in relation to density.

Material Needed:

1. Mercury
2. Water
3. Kerosene
4. Pebble
5. Piece of paraffin
6. Cork

Procedure: Pour the mercury, water, and kerosene in a large glass. Then drop the following: pebble, piece of paraffin, and cork (one at a time) into the glass.

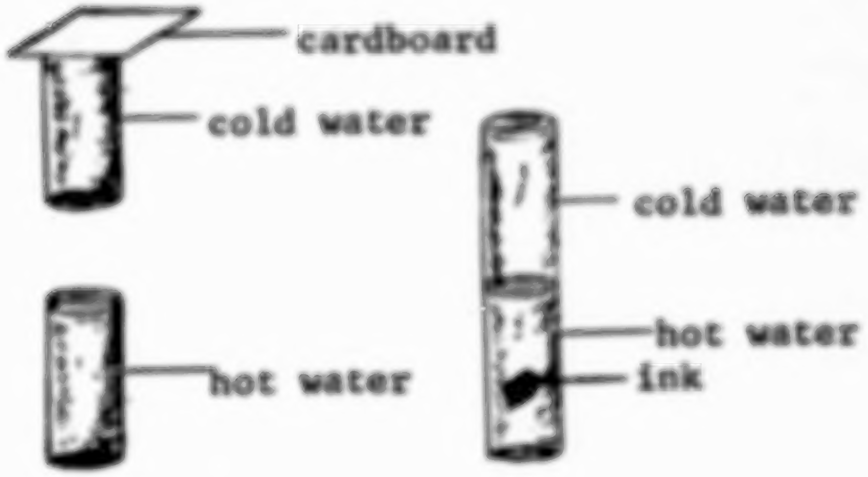
Experiment # 3

Purpose: Observe convection currents.

Procedure: Heat water in a transparent container with rice grains. Try and notice the directional pattern of the moving rice.

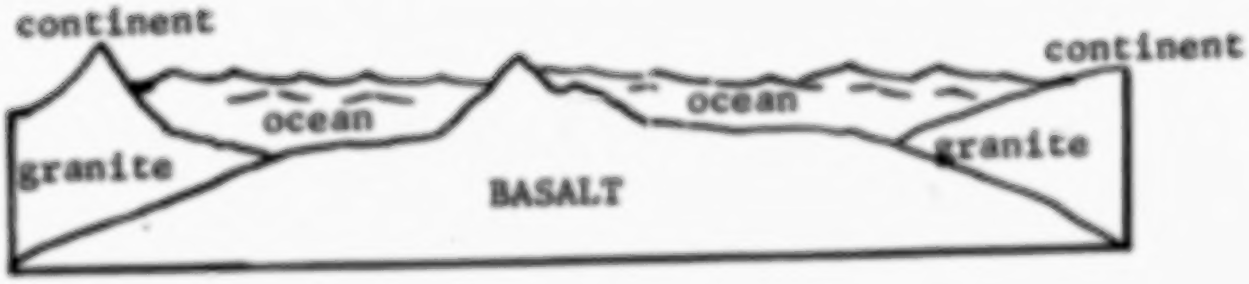
Experiment # 4 **Purpose:** Observe convection currents.

Procedure: Warm water and add to it a few drops of dye (or ink). Place a cold jar of water above the warm jar, observe the convective currents.

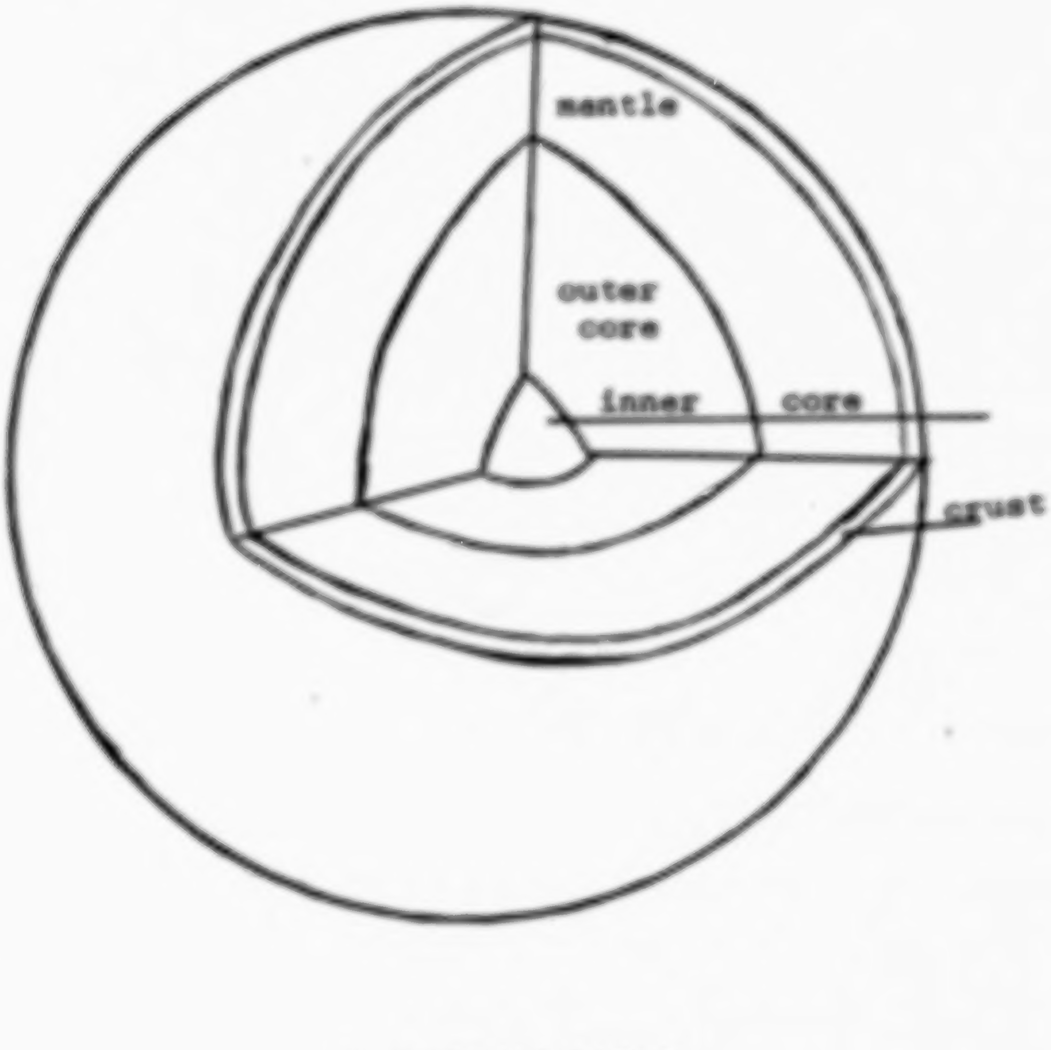

cardboard
cold water
cold water
hot water
ink
hot water

Glass filled with hot water. Deposit soluable ink in a center of hot water with a fountain pen. Then invert glass of cold water with a small card held over the mouth of the glass. Place over hot water and remove card.

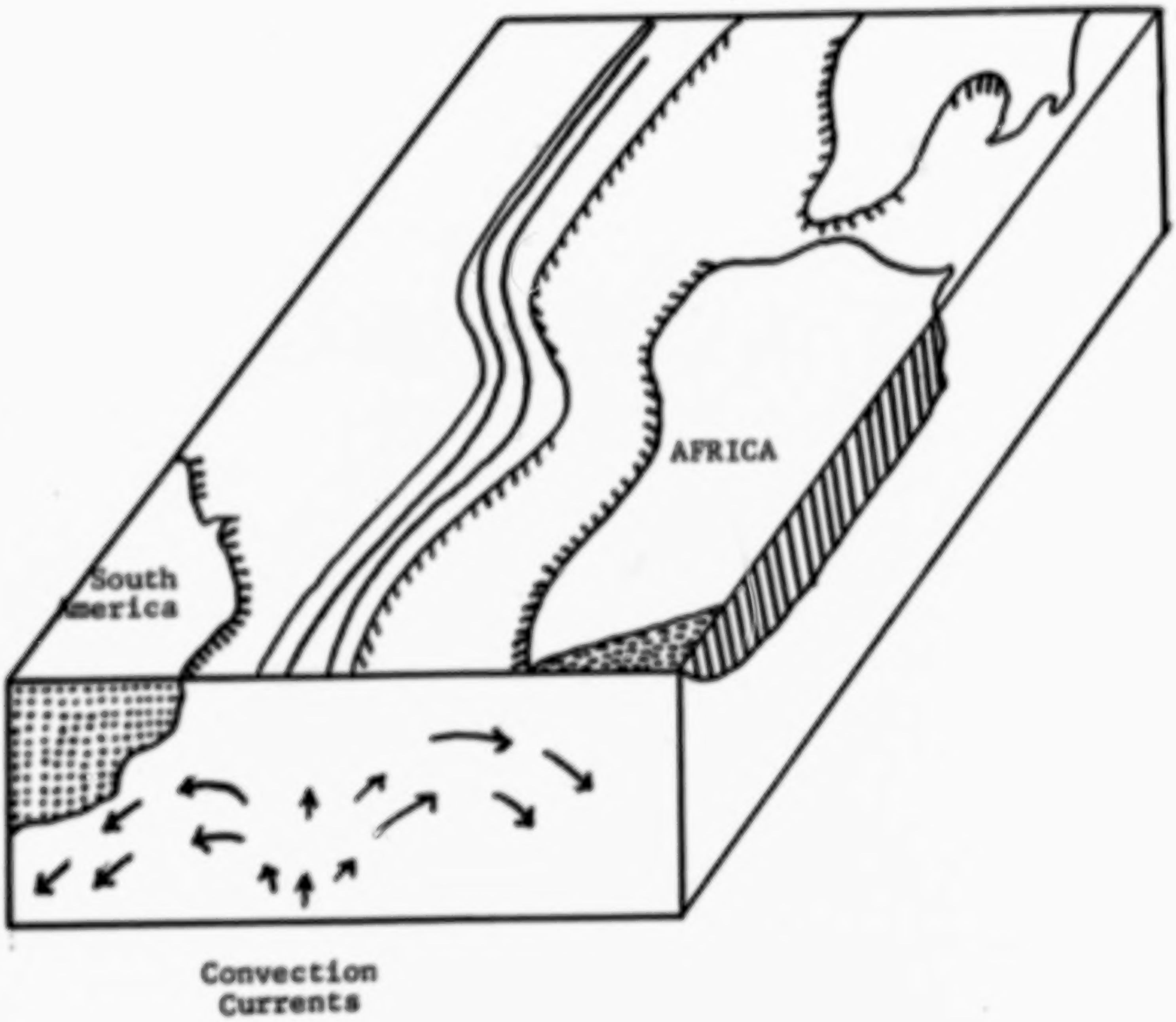
Field Trip: Visit older buildings, note variations of glass thickness in older window panes.


continent
continent
ocean
ocean
granite
granite
BASALT

Crust of Earth: Cross section illustrates relationship of oceans, continental masses (mainly granite), and underlying rock (mainly basalt). Vertical scale is exaggerated to show details more clearly.
Diagram: The Story of Geology, Wyckoff.


mantle
outer core
inner core
crust

INSIDE OF EARTH



Heat convection currents from beneath the earth's crust rise from the earth's mantle up through the Mid Atlantic Ridge. The heat may be forming both the mountain range and pushing the continents farther and farther apart. The seam of the real continental split may be the deep valley running down the center of the range.

Diagram drawn from Weekly Science Newspaper, Current Science, November 9, 1966.

EVALUATION

1. What type of movement would be great enough to move a continent?
2. What is the layer below the earth's crust and why is it important?
3. How have modern oceanographic instruments helped explain the ideas of continental drift?
4. Are there any new evidences of continents moving? If so, where are they?

C. Mountain Forming

One of the greatest unsolved problems of geology is the origin of mountains. In an attempt to solve this problem, geologists put together all the facts and observations they have at their disposal in an effort to reconstruct the past. Since mountains project so high and expose so many layers of rocks and fossils they, themselves, offer endless clues to their origin.

Geologists believe that the process called "folding" has formed most of the great mountain systems of the earth's surface. This was caused by sedimentary materials constantly being carried by streams and rivers into the oceans where they kept building up layer after layer. Through several million years heat pressure and chemical actions in these materials formed thick layers of rock. As the weight of these layers of sediment increased, pressure caused parts of the earth's surface to rise and wrinkle. Layers of rock were slowly lifted up and "folded." It is believed that the Rockies, Appalachians, Alps, and the Himalayas are folded structures.

Another type of mountains is the fault-block. It is believed that diastrophism on the mantle causes huge blocks of crust, some of them hundreds of square miles in area, to move up or down. The movement of these crustal blocks generally occur along deep breaks in the earth's crust known as faults. Layers of rocks along a fault are generally higher on one side than on the other. When a larger area of this crust is raised for some distance, we have the formation of block mountains. As a rule they are rectangular in shape and much longer than they are wide, but they vary greatly in size.

The largest of all block mountains of the United States are the Sierra Nevadas, which are over 400 miles long and two miles high. Others are the Wasatch Ranch in Utah, and many small ones in the Great Basin areas of Nevada, Oregon and Utah.

There are many small mountains such as the Adirondacks in New York, the Black Hills of South Dakota, and the Henry Mountains of Utah that are classified as dome mountains. These are formed when the earth's crust develops a weak spot and pressure of the plastic material that makes up the mantle forces its way upward to the surface and causes parts of the crust to rise in a dome shape. These mountains are never much more than 150 miles in diameter.

Volcanic mountains are formed by pressure produced in the mantle of the crust. If there is a weak spot in the crust, it is not strong enough to withstand the force and molten rock, steam, and gases may erupt to form a volcano. If this volcano continues to erupt time after time, layers of lava will build up a mountain.

The most recent volcanic eruption was Paracutin in Mexico in 1943. In the middle of a cornfield, rock and lave exploded and layer after layer of lava flowed out and cooled to form Paracutin, a mountain now over 9000 feet in height. Other volcanic mountains are Mount Popocatapetl in Mexico, Mount Etna in Sicily, Mount Rainier in Washington, and Mount Shasta in California.

The rate at which mountains rise and fall varies with time and location. Very little is known about this at the present time as accurate measuring devices were invented only a short time ago, and there has not been enough change in the heights of mountains to record the difference. At the present time Mount Everest in the Asian Himalayas at 29,141 feet is the highest peak on earth. Whether it will remain the highest is yet to be seen, for it is entirely possible for a mass of rocks to be thrust 35,000 to 40,000 feet high.

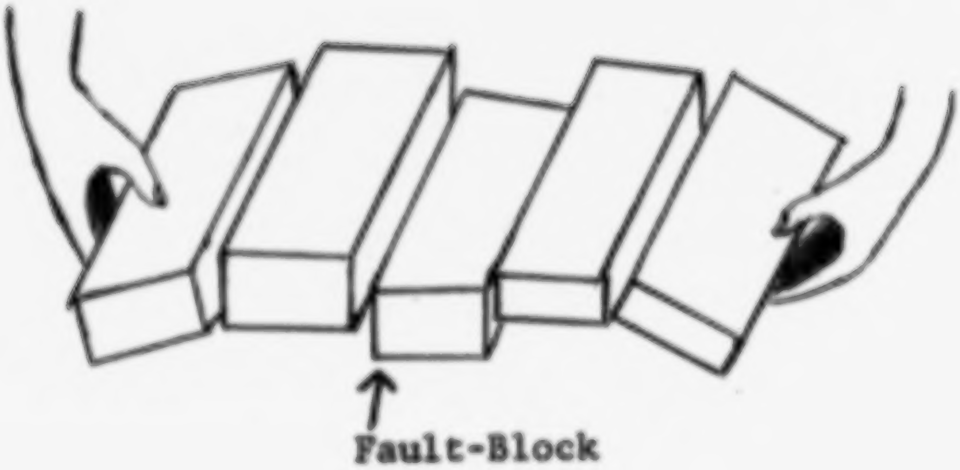
Even mountains suffer from old age, for when erosion continues for extremely long periods of time they may be worn down until they are almost level.

Even though the cold climate, rocky soil, and steep slopes make mountains poor farming areas, they are valuable to man in many ways. Water for irrigation and electric power comes from the rushing streams, and grasses for grazing grow on the humid slopes. Rich deposits of valuable mineral ores are frequently found near the surface of the earth because streams expose the strata that contain rich veins. In addition, large quantities of gold, silver, lead, zinc, copper, and iron are mined from the mountains. Some of our most beautiful buildings in the United States are made from granite, marble, slate, and sandstone that comes from mountain quarries.

Activities

1. Make plasticene or plaster of paris models of fold mountains, fault-block mountains and dome mountains.
2. To illustrate domed mountains, attach a rubber balloon to a long piece of glass tubing and put the balloon in a large pan or box. Arrange the glass tubing so you can blow up the balloon without moving it. Put several inches of soil over the balloon and begin to carefully blow through the tube. What happens to the soil? If you tied the balloon and allowed the air to remain in it, what would happen to the soil?

3. Spread a thick layer of soft modeling clay or soil clay in the bottom of a small box. Flatten the top of the clay and put a piece of wood over one half of the box. Place a brick on the wood and apply pressure. What happens to the clay in the other half of the box? Would this explain the rise of mountains on some parts of the earth's crust?
4. Build a volcanic cone with a deep depression in the top. Put some ammonium dichromate mixed with a small amount of powdered magnesium.
5. To illustrate the formation of folded mountains, take a slab of modeling clay 4 by 12 inches and 1/2 inch thick. Place the clay on a sheet of wax paper flat on a desk top. Cut the clay into two parts at the center. Push the ends slowly together. As the ends are pushed together, one half tends to override the other half.
6. The formation of fault block mountains may be illustrated by taking 5 blocks of wood and setting them up side by side on a table top. Apply pressure to the end blocks by pushing them together until the center blocks are forced upward; then release the pressure by pulling the end blocks apart slightly. The center block will fall a little lower than the ones on the side as in the picture. (see next page)


Fault-Block

CHAPTER III

If I were to travel about the ocean depths in a nuclear submarine what unusual formations and forces should I be prepared to cope with regularly?

Objectives

1. If I could drain all the water out of the oceans, what would the resulting ocean bottoms look like?
2. What kinds of materials might I find on the floors of the oceans?
3. What sorts of minerals can I mine from the oceans?
4. How does the water in the oceans circulate so that it doesn't become stagnant?
5. How can I explain why water is higher on the beach at some hours during the day than it is at other times?
6. How can I demonstrate the different types of waves that are found on our oceans?
7. What were some of the problems that were encountered in Project Mohole?

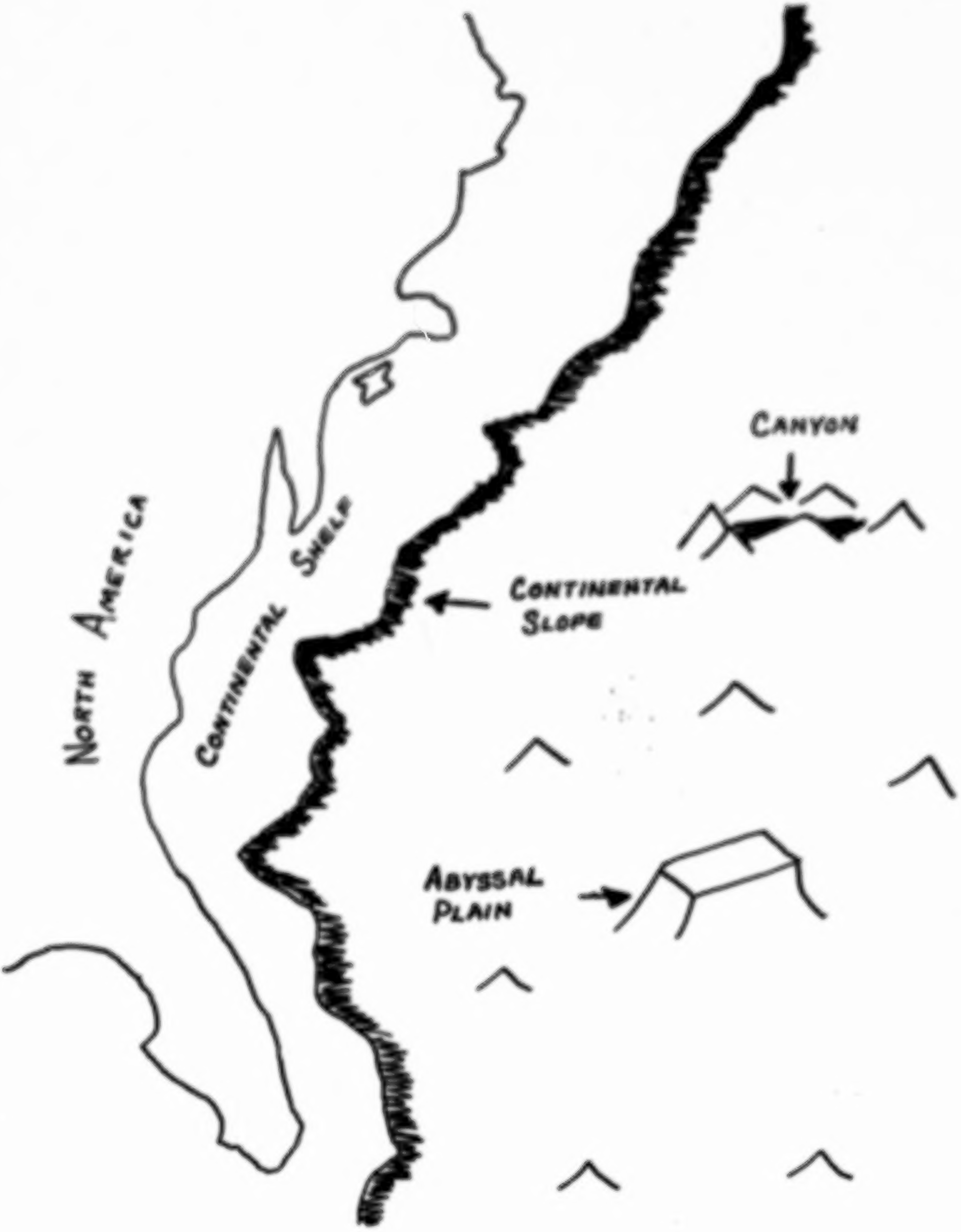
3.1 What are the major geographical structure that I would encounter along the ocean floor.

A. Continental shelves

If all the water were drained out of the oceans, they would appear as huge basins surrounded by a continental shelf. This shelf is the wide, gently sloping area around the continents. The shelf is actually just a part of the coastal plains that extends seaward for hundreds of miles under the water. The gently sloping continental shelf gradually becomes steeper and then it is called a continental slope. At the end of the continental shelves, the depth usually ranges from 300 to 600 feet, though the average depth is about 400 feet. Continental shelves are actually almost level and have a slope of only a few feet per mile. They extend many hundreds of miles into the ocean from the continents. The shelves are very narrow or almost absent from some continental shores, though both the American and the European side of the North Atlantic Ocean have large shelves.

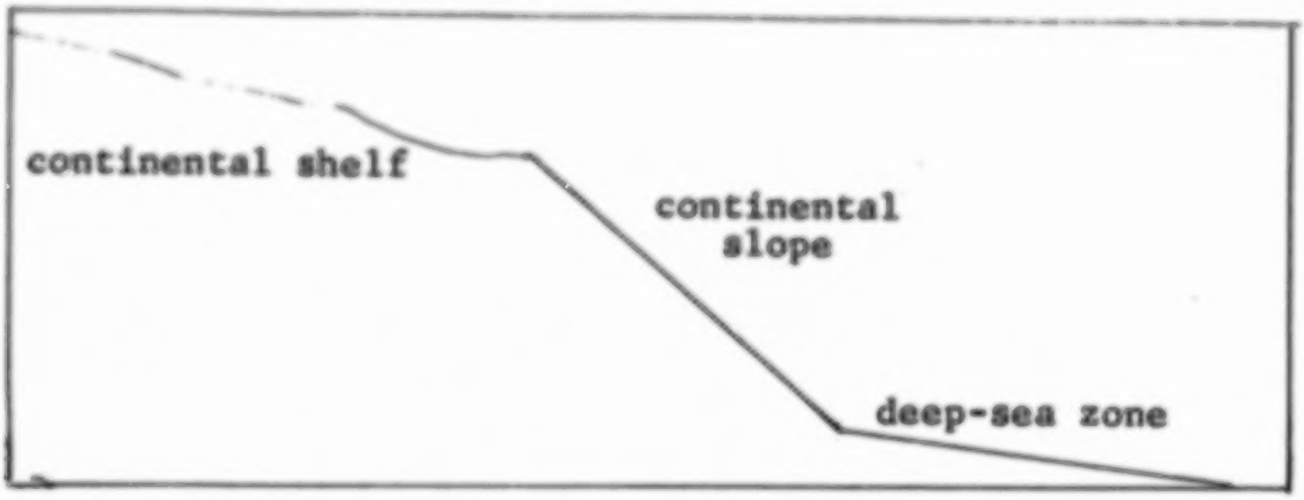
Continental shelves consist of sedimentary rock which geologists think was deposited in ancient seas. This sedimentary rock is a good source of oil and petroleum, thereby making continental shelves important because of their mineral rights. The United States took possession of all the shelves adjacent to its shores in 1946 because of the mineral rights.

Rivers flowing into the oceans leave deposits on the continental shelves which consist of gravels, sand, clay, shell deposits, and silts. When these deposits become several hundred feet thick, their lower layers harden into rock. Tremendous pressure on fine materials like silt and clay on bottom layers make the particles stick together and become compacted. Coarser sediments of gravel and sand particles do not hold together unless they are cemented. These processes form the sedimentary rock of which the continental shelves are made.


CANYON
CONTINENTAL SLOPE
ABYSSAL PLAIN
NORTH AMERICA
CONTINENTAL SHELF

B. Continental slopes

At the edge of the continental shelf the slope of the sea floor increases rapidly to as much as several hundred feet per mile. This area is called the continental slope. It is in this area that many landslides occur. Rivers wash out much material onto the continental shelves and some of it is carried out as far as the continental slopes. When a large amount of this material accumulates, its own weight causes it to break loose and slide to the sea floor. The large mass of sliding material creates strong, muddy currents known as turbidity currents. These currents are believed to have cut the deep canyons in the edge of the continental shelf. Beyond the continental slope is the deep-sea zone which covers the major part of the ocean.



C. Coral Reefs

Coral reefs are found in warm, tropical waters since the coral forming animals must have a temperature of at least 65° F. For this reason reefs abound throughout the South Pacific, in the East Indies, and the Indian Ocean.

Corals belong to the group of animals known as Coelenterates which live in a variety of strange and beautiful colonies. They live in clear, warm, shallow waters in the sea. They extract calcium carbonate from the water to build their hard skeletons or shells in which they live. They reproduce by budding and usually stay attached to each other to form colonies. When the corals die, the shells of their colonies are left and other generations of corals grow above them.

Three typical forms of coral reefs are the fringing reefs, the barrier reefs, and the atolls.

Fringing reefs which occur along the coasts of Florida and Bermuda are those that grow close to the shore and far out from the edge of the land in an almost solid shelf.

Barrier reefs follow the shore line but are separated from the mainland by broad lagoons of quiet waters. They form a barrier between the water near the shore and the open sea. This type reef usually surrounds volcanic islands of the South Pacific. The Great Barrier Reef of

Australia which is 1,260 miles long and 500 feet high is the most magnificent coral reef in the world. The outer edge is 7 miles from the mainland in some places and as much as 100 miles in other places. Between the reef and the mainland is a broad lagoon called the Inland Waterway. Coastal ships travel this "grand canal" but it takes an experienced sailor to pick his way through the reefs.

Atolls are ring-shaped coral islands in the open seas. They are found when coral builds up on a submerged mud-bank or on the rim of the crater of a sunken volcano. They enclose a lagoon, but there is no island in the lagoon. They are found chiefly in the open waters in the middle of the Pacific Ocean. During World War II we heard much about Wake and Midway, atoll reefs, which were and still are refueling bases for trans-Pacific airplanes.

D. Deep sea trenches and other geographical structure occurring along the sea floor

During the last 30 years the ocean bottom has become the main frontier of exploration on the surface of our planet. The vast area hidden in the darkness of the deep sea (nearly 3/4 of the earth's surface) is slowly being explored and mapped for the first time. Lately with the help of the Echo Sounder (Sonar) scientists have "seen" enough to realize that if the oceans were somehow drained of water, they would expose a vast landscape--mountains taller than Everest, plains as vast as The Russian Steppes, and gorges rivaling the Grand Canyon.

One of the most unusual features of the sea floor is a series of underwater mountain ridges called mid-ocean ridges. Such a mountain chain, the Mid-Atlantic Ridge, averaging 200 miles in width and about 10,000 feet in height, stretches along the entire basin of the Atlantic to the Southern tip of Africa. There it turns to join with a similar ridge running through the Indian Ocean. The Indian Ocean Ridge in turn joins with several ridges which reach across the Pacific. The peaks of these ridges are higher than most mountain systems, yet their peaks, in most cases, are a mile or more below the surface. The Azores, Ascension Islands, and other scattered islands of the Atlantic are the highest peaks. The complete extent and origin of these underwater mountain systems is not fully known, but they are thought to be the result of volcanic activity along a great system of fractures in the crust.

Associated with the islands are deep gashes in the sea floor called trenches. These trenches may have formed by the faults in the sea floor, along which occur the volcanic eruptions that have produced the islands themselves. All the deepest spots in the oceans are located in these trenches. The deepest so far measured is a trench near the Mariana Islands in the Pacific Ocean named the Tonga Trench. It is over seven miles deep in places and is 1500 miles long.

Two other theories concerning the formation of the trenches should be considered. One idea is that the deep canyons were cut by actual rivers during the ice ages when the oceans were lower than now and the continental shelves stood at sea level. Another hypothesis is that the canyons were eroded by submarine flows, or avalanches, of silt-laden water, called "turbidity currents." These currents filled with masses of material flowed by gravity as currents down the slope at the edge of the continental shelf, and in so doing they eroded canyons in the slope.

Other particularly deep trenches are located near the Aleutian Islands, off the coast of Japan, near the Philippines and Java, and off the west coasts of Mexico, Peru, and Chili. These trenches are all about six miles deep and up to 2000 miles in length.

Another feature along the ocean bottom is that of the abyssal plain. The abyssal plain has been defined as, "an area of deep-ocean floor in which the bottom is flat and the slope of the bottom is less than 1:1000." They are formed by deposition of sediment which is apparently distributed by turbidity currents. These currents are flows of mud and sand that can travel up to fifty miles per hour. This evidence has been substantiated by breaks in cables that have been placed on the ocean floor. In taking samples of this mud it has been found to contain coarse sand and fossils of dead marine life. The thickness of these sediment deposits suggest very rapid deposition due to the accumulation and thickness of the deposits. These sediments may be divided into red clay, which constitutes the majority of the sediment, and shells of marine organisms which have died.

All of these features--the continental shelf, continental slope, deep-sea trenches, and the abyssal plain--are located beneath huge masses of ocean water. The origin of ocean water comes from igneous rock which lost its water by hydration. This rock was forced to the surface of the earth by volcanic action. In turn glacier melting caused the ocean floor to rise and made changes in the sea level. These changes are classified in different categories: (1) Geodetic changes - This change is brought about by the inclination and speed of rotation of the earth. The tilting changes would in turn bring about current patterns and the slowing of rotation will bring about changes in the shape of the earth which in turn would affect the sea level. (2) Tectono-Eustatism - This refers to changes in the capacity of the ocean basin which is due to the movement and erosion of the earth's crust. (3) Sedimento-Eustatism - Involves the filling of the ocean basin with dead microscopic organisms.

(4) Glacio-Eustatism - Is the recovery of land masses to a higher level due to the removal of masses of ice by melting.

Evidence of these changes may be found in beaches which exist on dry land, submerged forest, layers of peat bog that alternate with salt marsh silt, and radio-carbon dating. (Radio isotopes of carbon that exist in the layers of the material which exist in the ocean and on dry land that was once covered by the ocean.) It might be concluded, perhaps, that the sea level would not solely depend on water amount, but also on the height of the land and depth of the ocean basin.[1]

3.2 What are the forces and conditions that I must cope with in navigating my submarine in and on the ocean waters?

A. Characterisitcs of sea water

1. Salinity

Ocean water contains traces of essentially all non-metallic and metallic ions. The important elements in sea water are used by living organisms for reproduction and growth. Many of the trace elements are used for biological and commercial purposes. The proportion of the main constituents in sea water remains constant from different areas and for different total salinity.

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[1] Fairbridge, Rhodes W. "The Changing Level of the Sea"; Scientific American. Vol. 202, No. 5. May, 1960. pp. 7-79.

Reference for this part was taken from the above.

Major Components of Sea Water

Element	Per Cent	Element	Per Cent
Sodium	1.06	Potassium	0.04
Chlorine	1.09	HCO_3	0.01
Magnesium	0.13	Bromine	0.0065
Calcium	0.04	Flourine	0.0001
Strontium	0.01	Iodine	0.000005
SO_4	0.26		

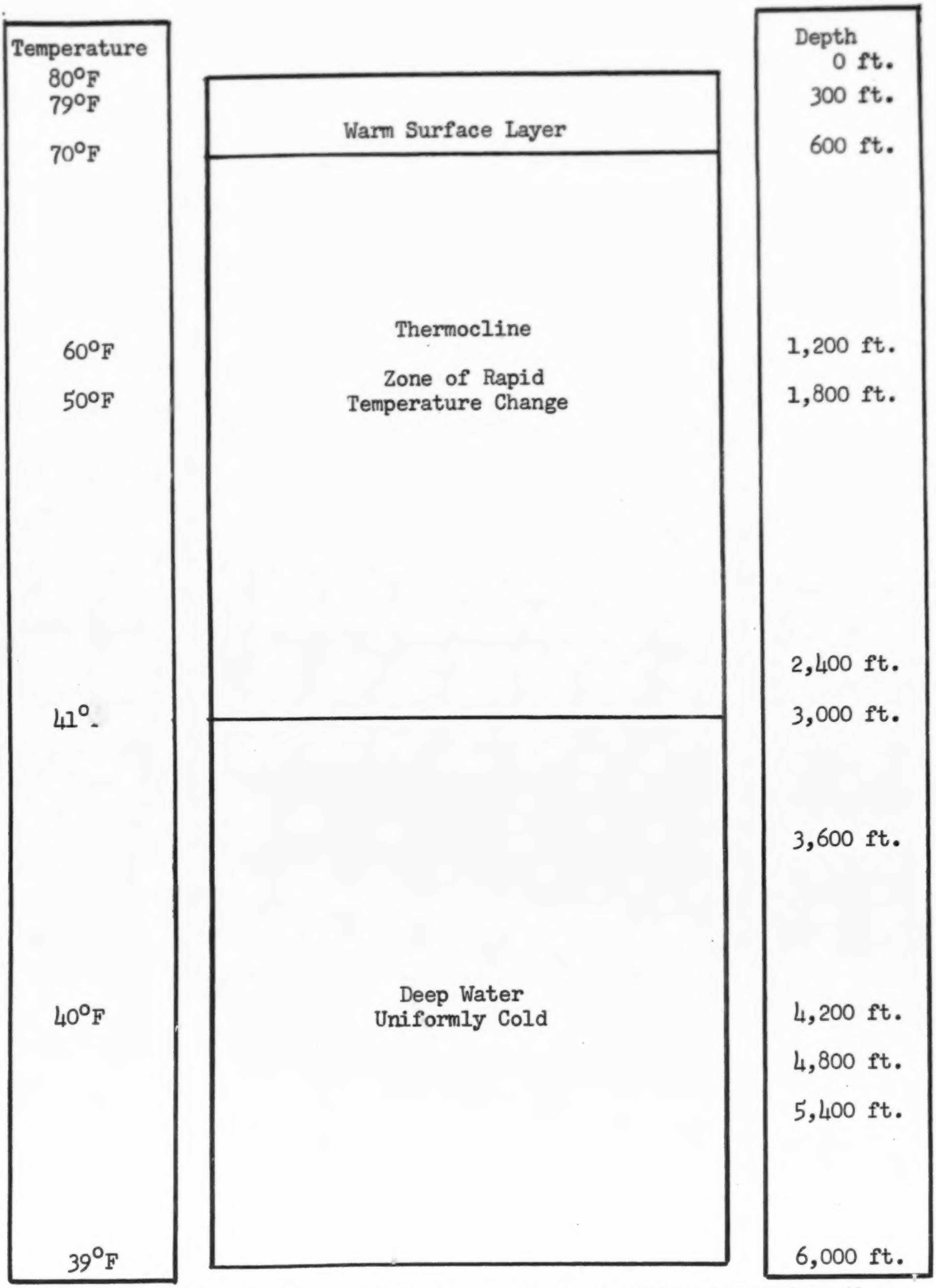
2. Temperature

The principle source of the ocean's heat is the sun's rays which do not pentrate very far. The surface temperature of ocean water ranges from about 80° F. at the equator to about 27° F. at the polar region. The ocean temperatures do not vary greatly throughout the year. However there is an important seasonal fluctuation of surface temperature in the oceans and this varies with a number of factors, such as prevailing winds, ocean currents and density.

The great depth of which heat is distributed in the oceans depend on four factors:

Vertical motion of the water
Effect of heat conduction
Variation in the amount of heat absorbed
Lateral displacement of the water by currents

Ocean temperatures decrease rapidly with depth and the low temperatures of water deep in the ocean are maintained by the movement of the cold water along the ocean floor from the polar region to the equator.


Temperature
80°F
79°F
70°F
60°F
50°F
41°
40°F
39°F
Warm Surface Layer
Thermocline
Zone of Rapid Temperature Change
Deep Water Uniformly Cold
Depth
0 ft.
300 ft.
600 ft.
1,200 ft.
1,800 ft.
2,400 ft.
3,000 ft.
3,600 ft.
4,200 ft.
4,800 ft.
5,400 ft.
6,000 ft.

How ocean waters in equatorial region change in temperature from the surface downward.

3. Water masses

Water masses are homogenous bodies of water and can best be defined by their salinity and temperature. To describe water masses, density along cannot be used because two water masses can have the same density but different salinity and temperatures.

Water masses are stratified in the oceans according to density. The dense water masses occupy most of the ocean basins and above the deep water on the surface are the shallow water masses.

Surface Water Masses	Centigrade Temperature-C	Salinity
Antartic surface water	-2-1	33.0-34.5
Arctic surface water	3-4	29.7-33.0
North Atlantic central water	8-19	35.1-36.7
South Atlantic central water	6-18	34.5-36.0
Subantarctic water-all oceans	4-8	34.2-34.4
Subarctic Pacific water	2-8	32.0-34.0
Western North Pacific central water		34.7
Eastern North Pacific central water		34.6
Pacific equatorial waters	8-15	34.6-35.2
Western South Pacific waters	8-15	35.6
Eastern South Pacific waters	10-18	35.1
Indian equatorial water	4-17	34.9-35.3
Indian central water	8-15	34.6-35.5

Surface and Deep Water	Centigrade Temperature-C	Salinity
Antarctic circumpolar	2-7	34.7-34.8
Deep Water Masses:		
Antarctic intermediate water	2-7	34.1-34.6
Intermediate water-north Atlantic	3-4	34.9
Mediterranean water	13-14	38.4-38.7
North Atlantic deep and bottom water	3	34.9-35.0

B. Circulation of the ocean

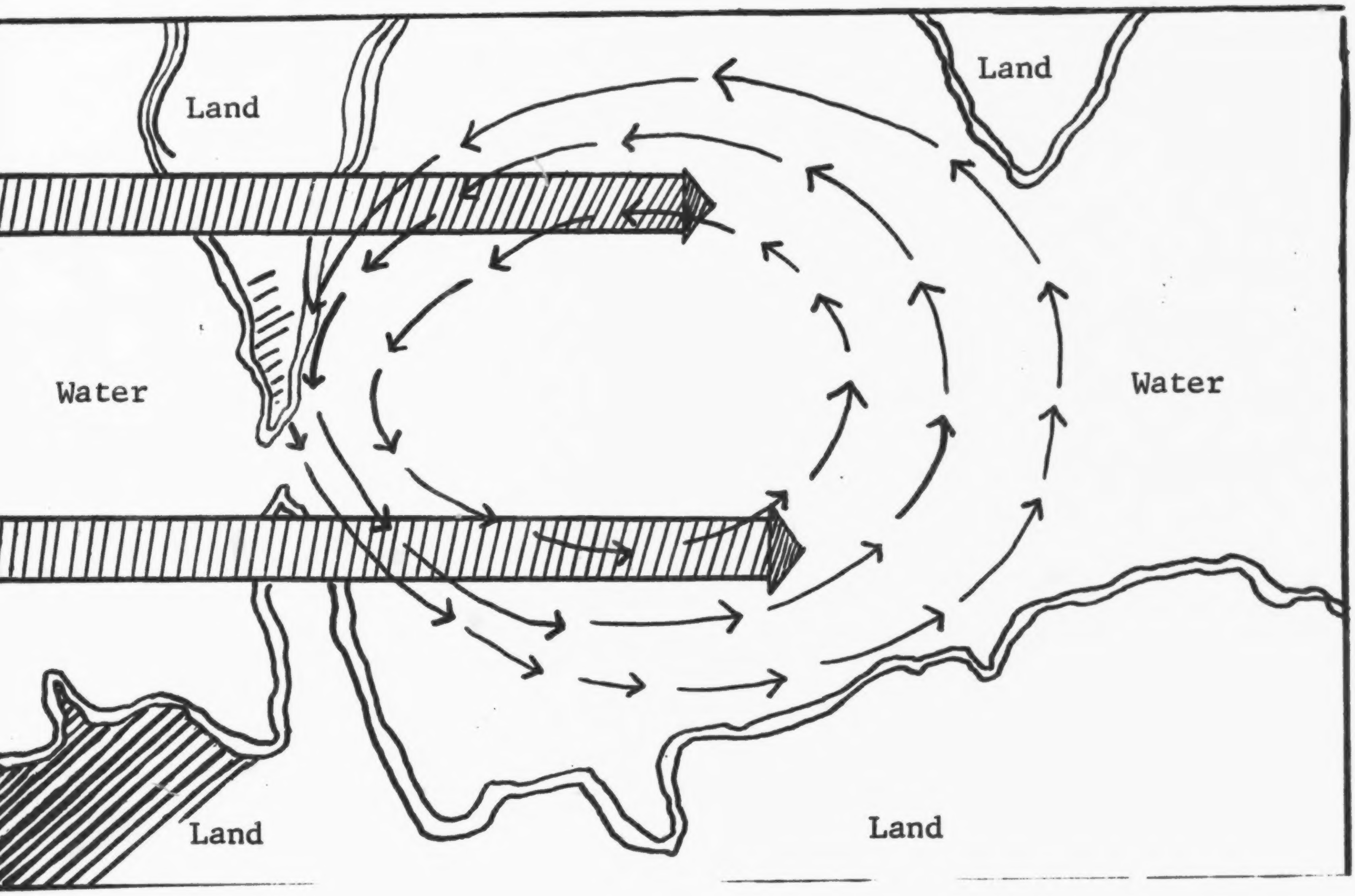
The circulation of the oceans helps to distribute heat, and the fertile areas of the ocean depend to a considerable extent on oceanic circulation. The factors to be considered are the force due to the pressure gradients, force of gravity, the forces of friction, inertia and rotation of the earth.

Circulation of the ocean depends on two factors, wind stress and density. Wind stress may be balanced by the coriolis force only, without pressure gradients arising. Wind can move water by frictional force and it also accelerates the motion of water as it picks up spray and throws it down again. Another means by which wind drives ocean water is its pressure on the waves as it sweeps over rough water because pressure is higher on the windward side than on the lee side. Driving winds produce great circulation in the oceans because the wind is stronger at some latitudes than at others and the stronger will overpower the weaker and the water will begin to circulate. The circulation will be greater if the winds at different latitudes blow in opposite directions. The earth as it rotates exerts a torque on the circulation of the ocean, with the result that the center is displaced toward the west and the currents are intensified on the western side. The boundaries of the major currents are where they should be in relation to wind systems and the strong western currents appear where they should be.

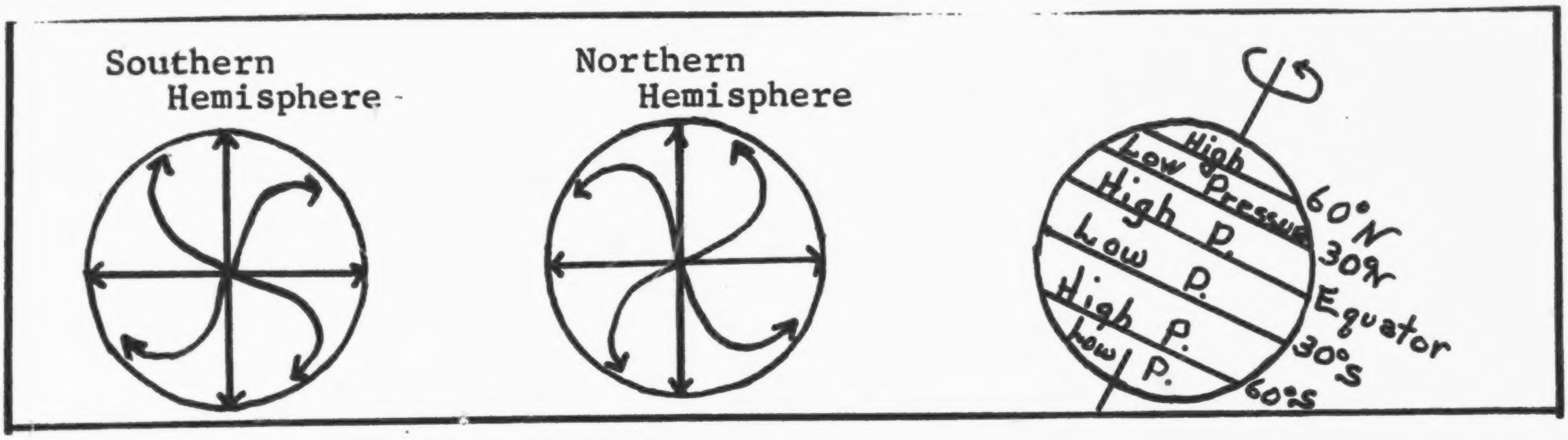
The difference in the distribution of mass of density are important to circulation. The distribution of salinity and temperature are important to the movement. The thermocline effects are also important; heating of the surface layer and poleward flow at the surface, sinking of the heaviest water in the highest latitudes, spreading of water towards the equator in the deep layers, and ascending deep water through the thermocline into the surface layer. The main features of the thermocline origin are the ascending water associated with it in low latitudes and the sinking of deep water in high latitudes.

Features of the wind circulation are the Antarctic Convergence, ascending deep water in high latitudes, surface circulation, and the sinking of the Antarctic Intermediate water.

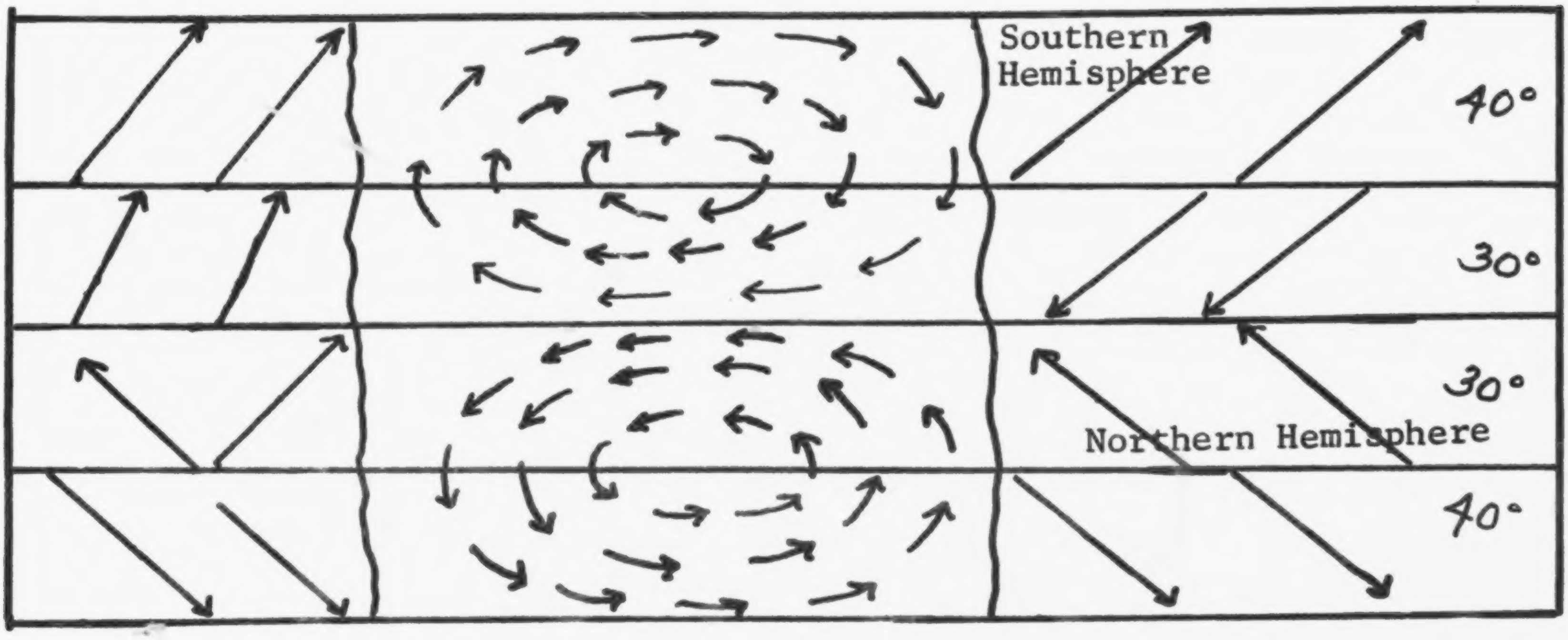
Circulation of the Oceans


Land
Land
Water
Water
Land
Land

Coriolis Effect


Southern Hemisphere
Northern Hemisphere
High
Low Pressure
High P.
Low P.
High P.
Low P.
60°N
30°N
Equator
30°S
60°S

Fluid Movements in Hurricanes and Whirlpools



Activities

1. Make a wave tank for reference study. Easily made with boards or bricks and polyethylene film.
   a. Show wave patterns
   b. Breakers
   c. Undertow
2. Make charts of tides and currents associated with some particular area.
3. Compare the thickness of the oceanic crust with the Continental Crust.
4. Make waves turn an electric fan on water in a shallow pan. Increase the force of the fan. Place a rock in the water and observe what an obstruction will do.
5. Read about Tsunamis.

C. The Ocean Tides

What are tides? Tides are the daily rise and fall of the waters of the oceans and their inlets on a definite time schedule. All bodies of water are subject to the forces which produce tides, but it is only where great bodies of water meet land, that they are large enough to be noticed.

1. Tide producing forces

What are some of the forces which produce tides? Men have known for thousands of years that the moon had some bearing on the tides, but the relationship only became understood after Sir Isaac Walton formulated his laws of gravitation. Because of gravitational pull, all heavenly bodies exert a force on bodies of water, the amount of pull depending upon the mass and distance from the earth. Since distance bears an inverse relationship on gravitational pull, the side of the earth facing the moon experiences a slightly greater pull than the opposite side, causing a tide. This force also tends to pull the solid earth away from the waters on the other side of the planet, causing a corresponding, but lesser tide on the other side of the body. At perigee, the moon is approximately 30,000 miles nearer the earth than at apogee, causing a difference in the height of tides. The sun is more than 27,000,000 times larger than the moon, but 390 times as far away, so its influence is not as great. The bulge of tides on the side of the earth facing the moon is known as the direct tide, and those on the opposite side are called the indirect. Since the earth's rotation tends to carry the tidal bulges forward from their position in line with the moon, high tides do not occur for several hours after the moon passes directly overhead.

Twice monthly, at full moon and new moon, the sun and moon are in line with each other and effects of both are felt at once. At these times, tides produced may be considerably higher than usual. These are known as spring (no relation to the season) tides. At first and last quarter, the sun and moon are at right angles to each other, causing lower tides, since each tends to flatten the tidal bulges caused by the other. These periodic lower tides are called Neaptides. When the moon is closer to the earth at times of spring tides, they may be a great deal larger than usual. Tides always move with the apparent revolution of the moon around the earth, so it follows that the tidal cycle has about the same interval as from one rising of the moon to the next, or about every twenty four hours and fifty minutes.

2. Response to tides

How do the waters of earth respond to these external forces? It is readily apparent from the difference in timing and size of the tides in different places that each part of the sea fluctuates in its own particular way to the rhythmic gravitational pull of the moon and sun. Even though the sea is all one body of water, it is divided into different parts by the irregularities of the sea floors and the positions of the land masses. Each part seems to have its own pattern for tidal movements. Both size and depth of the basins seem to be critical factors in determining the motions known as tidal oscillations. These slow, rocking motions occur in the ocean in response to the bulges of tides, whose rhythm either dampens or reinforces oscillation in different parts of the ocean. While they are not particularly pronounced on a straight coastline, they become enormous in some small bodies of water, such as the Bay of Fundy in Nova Scotia. Here, the difference between high and low tides is as much as sixty-two feet.

Often the movement of seas caused by tides and oscillations cause extremely violent currents to exist. In some harbors it is virtually impossible for ships to enter or leave except for the periods between tides. At any other time, the rush of waters makes it dangerous for ships to negotiate passage.

When a large river empties into a harbor with an unusually high tide, or when it is blocked by a sand bar, a condition known as tidal bore often occurs. As the tide rises, it causes a wall of water opposing the river to flow upstream. Usually this tidal bore will exhaust itself after a few miles, but in the case of the Amazon River, it often travels as much as two hundred miles upstream. The highest tidal bore in the world is in the Tsientang River, which empties into the China Sea. During Spring Tides, this wall of water sometimes reaches a height of twenty-five feet and moves upstream at speeds approaching fifteen miles per hour.

In many cases, it is possible to utilize the tremendous energy contained in the rush of water in the tides. Dams may be constructed to trap the waters when they are at high tide, and release them gradually so that electric power may be generated. This has been done on the Rance River in France, which has tides of some thirty-seven feet. Once these facilities are constructed, they would seem to furnish power indefinitely at a low cost.

D. Ocean Waves

What are waves, and how are they described? Waves are created when the surface of a body of water is disturbed. Basically, the waves on a small pond are no different from those in the ocean. All waves have certain characteristics in common, regardless of how large they are, or how large the body of water is. All waves have two basic parts, the crest, which is elevated higher than the surrounding water, and the trough, which is depressed lower than the surrounding water. A wave is described by its height, the distance from the bottom of the trough to the crest of the next one;

the wavelength, the distance between crests; and the period, the time taken for two consecutive crests to pass.

1. What are some types of waves?
    a. Wind waves are disturbances of bodies of water which are stirred up by the friction created when wind blows across them.
    b. Tsunamis are generated by earthquakes or volcanic disturbances. They travel at speeds up to five hundred miles an hour, with periods of several hours, and have wavelengths of one hundred miles or more. Only about 225 tsunamis have occurred in recorded history, but they have caused unbelievable destruction. They often reach heights of more than one hundred feet.
    c. Seiches. All enclosed bodies of water rock with characteristics related to the size of the basin. In their effort to reach stability, water sways back and forth, creating waves. This action is comparable to the way water rocks back and forth in a bath tub.
    d. Another type of wave travels along the thermocline; that is the surface where the warm and cold layers of the ocean meet. They cannot be seen, but thermometers prove they exist and are moving slowly along this junction of waters.

   e. Storms at sea cause certain types of waves to arise, which have a long period of several minutes. These waves, traveling at high rates of speed, could be used to forecast storms at sea.
   f. Now being studied is another type of wave, which was discovered through statistical studies. These waves have periods of days or weeks, and sometimes a height of less than an inch.
2. What factors influence waves and their characteristics?
   a. Probably the single factor which affects waves most is the wind. As wind moves across the water, its friction creates minute disturbances known as wavelets. As more and more wavelets are created, it becomes easier for the wind to push the water into larger waves, which continue to grow as long as the wind blows.
   b. The amount of open water across which the wind blows is called the fetch. A strong, steady wind with a long fetch can build up huge waves. These conditions are most frequently encountered in storms, where waves 50 feet high are not uncommon. When the wind blows extremely hard, it may blow the tops from the waves, creating whitecaps. Since the wind rarely blows in

the same direction for a long period of time, and with the same strength, it causes waves of all sizes.

c. The water depth also plays an important part in the size and characteristics of a wave. The wave is made up of molecules of water traveling in a circular motion, with the diameter of the circle being the same as the wave height. As the wave moves into shallower water so that the water molecules rub along the bottom as they follow their path, the wave slows down. If the wave strikes the shore at an angle, the end entering shallower water slows down, causing the wave to approach the shore in a head on path, tending to erode points of land which stick out. As the wave enters shallow water, the circular motion is changed to an ellipse by the water being squeezed upward by the bottom. This motion causes the wave to pile up higher until the crest finally tumbles over into the trough and the wave becomes a breaker. The size of breakers is mainly determined by the steepness of the shoreline. If it shallows abruptly, the breaker grows rapidly, spilling violently into the trough.

A gradually sloping shore allows the wave to rise and fall forward gently. When the water strikes the beach and spends its momentum, it runs back into deeper water as an undertow, which is a current running seaward under the breakers. The rip current, a swift water current returning to deeper water through breaks in sandbars is dangerous. They usually last only a few minutes at a time, and can be identified by a break in the line of breakers.

3.3 How are the hydrosphere and the lithosphere interacting?

A. Sediment of the ocean

Almost all of the ocean floor is covered by a blanket of sediment ranging from a few mm. to more than 2,000 feet deep. The composition of this sediment is determined to a large extent by the depth of the water and the distance from land. The continental shelves and slopes are covered with deposits of gravel, sand, clay, and shells. Since it takes more force to move larger fragments of rocks, they are usually found nearer shore, while farther out are the fine particles or mud.

Beyond the continental slopes, the sediments are generally composed of soft, fine oozes or muds. Mainly, they are composed of small shells of sea organisms which have died and drifted to the bottom. They also contain traces of volcanic dust, land, and meteorite dust.

The oozes on the ocean bottom are of two types. A single-celled animal named Globigerina, deposits a calcareous sedimentation made of lime. Sileceous are oozes made of silica, are deposited by the remains of a one-celled animal named Radiolaria, and from unicellular plants called diatoms.

Deposits of almost pure volcanic ash have been found in water miles deep off the west coast of Central and South America. In the polar regions, icebergs drop large deposits of sediments as they melt.

In the trenches, or very deepest parts of the ocean, there are often deposits of a fine red clay, which is almost entirely rock, volcanic and meteorite dust. No shells are found, and it is generally believed that at these depths and pressures the sea waters contain enough CO_2 to dissolve the minerals in the shells. The red color seems to come from the rusted iron of the composite dusts.

As early as 1875, the Challenger expedition discovered nodules composed chiefly of manganese dioxide, and ranging in size from a foot in diameter, down to less than an inch. They are believed to have resulted as a deposition from the sea water around various nuclei on the sea bottom. It is estimated that the valve of these deposits run to as much as $500,000 per square miles.

Since the sedimentation rate is only about .4 inch per 1000 years, the ocean bottoms can furnish us invaluable information about long ago events.

B. Project Mohole

There is a great store of information to be found in the earth's crust and its lower layers. Scientists feel that it will be more feasible to drill to the boundary between the crust and mantle over the ocean. The National Academy of Science planned to do this, since the crust is thinner under the ocean. The first Project Mohole was drilled west of San Diego, California, where they brought up samples which geologists felt might be a million years old. The project was abandoned because of a lack of funds.

CHAPTER IV

An experimental aircraft is placed at my disposal which will enable me to investigate the atmosphere to an altitude of several hundred miles. While traveling at different elevations, what variations will I encounter over the surface of the earth?

UNIT II. THE EARTH'S ATMOSPHERE AND WEATHER

Objectives

1. How can I identify the different belts in the atmosphere surrounding the Earth?
2. What chemicals can I find in the atmosphere?
3. If I wish to travel in outer space, what are some of the hazards which do not endanger me on Earth?
4. How can I be certain that air has weight, and how does this weight affect my welfare?

7 neg.

A. What belts will be encountered as I move vertically away from the surface of the earth?

The objective of this section is to explain as clearly as possible some of the salient features of the atmosphere, and how the atmosphere enhances man's progress and knowledge about the universe in which he lives. It should be clear that much is known about the atmosphere above us but there is yet a wealth of knowledge to be gained concerning the ocean of air above and around us.

We shall endeavor to give the reader a better perspective, at a glance, of the structure, composition and temperature ranges of this great gulf of air surrounding our planet.

We will see how we can measure some of the properties of the atmosphere and observe some of the phenomena which is basic to its nature.

Since man has made almost uncountable ventures into space, he has become increasingly aware of the dangers and hazards which could and do exist in the atmosphere above him. If his knowledge of what exists in our atmosphere is too limited, he is subject to grave dangers, so he has set out to learn about the atmosphere above by the use of unmanned space craft, weather balloons and satellites. These are vehicles which collect data and transmit it back to the earth.

Since we will be concerned in this chapter with both the earth's atmosphere and weather, let us first take a look at the earth's atmosphere and get a clearer view of its components.

The earth's atmosphere generally include the following zones and belts starting from the earth and moving vertically upward.

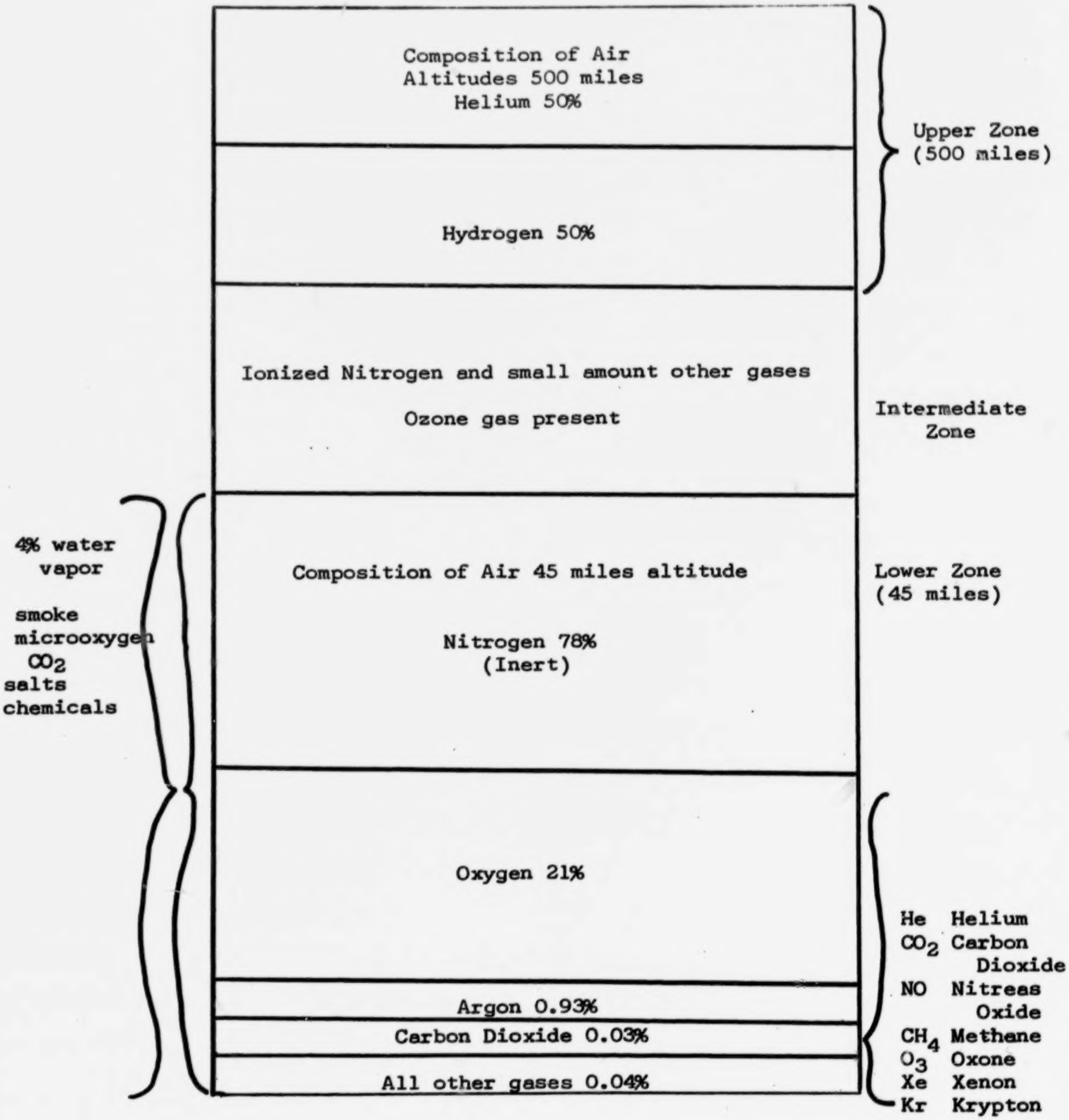
(1) Troposphere
(2) Tropopause
(3) Stratosphere
(4) Stratopause
(5) Mesosphere
(6) Mesopause
(7) Ionosphere or Thermosphere
(8) Exosphere

In the exosphere we leave the region of air almost completely. The atmosphere is so rare that the charged particles are too far apart to produce charged layers like those in the ionosphere.

The Nature of the Earth's Atmosphere

The earth's atmosphere and weather is mainly concentrated in the zone of the troposphere. The atmosphere is the envelope of gases surrounding the earth's surface and extending great distances to more than 300 miles. The atmosphere is a mixture of gases which we call "air." The farther we go up, the greater will be the change in the composition of the earth's atmosphere. At the upper limits of our atmosphere we find that there are swarms of electrons and protons from hydrogen nuclei as well as charged particles of atomic oxygen and nitrogen. Such a composition

RELATIONSHIP BETWEEN THE COMPOSITION OF ATMOSPHERIC GASES AND ALTITUDE


Composition of Air
Altitudes 500 miles
Helium 50%
Hydrogen 50%
Upper Zone
(500 miles)
Ionized Nitrogen and small amount other gases
Ozone gas present
Intermediate Zone
4% water vapor
smoke
microoxygen
CO_2
salts
chemicals
Composition of Air 45 miles altitude
Nitrogen 78%
(Inert)
Lower Zone
(45 miles)
Oxygen 21%
Argon 0.93%
Carbon Dioxide 0.03%
All other gases 0.04%
He Helium
CO_2 Carbon Dioxide
NO Nitreas Oxide
CH_4 Methene
O_3 Oxone
Xe Xenon
Kr Krypton

would be difficult for the maintenance of life as we know it.

The Composition of Air Near the Earth

Component	Percent by Volume	Component	Percent by Volume
Nitrogen	78.03	Neon	0.0012
Oxygen	20.99	Helium	0.0005
Argon	0.94	Krypton	0.0001
Carbon dioxide	0.035-0.04	Ozone	0.00006
Hydrogen	0.01	Xenon	0.000009

The composition of dry air will not vary much with location on the surface of the earth nor with altitude. (altitudes in the lower and middle zones) The pressure will vary greatly as one moves vertically upward. Average pressure at sea level and latitude 45° is 760 mm. of mercury (14 1/2 lb. per square inch.) At about 10 miles altitude the pressure drops to about 40 mm. of mercury.

Symbols and Formula Relating to the Earth's Atmosphere

1. N_2 - Nitrogen
2. O_2 - Oxygen
3. Ar - Argon
4. CO_2 - Carbon Dioxide
5. Ne - Neon
6. He - Helium
7. CH_4 - Methane
8. Kr - Krypton
9. N_2O - Nitrous oxide
10. H_2 - Hydrogen
11. O_3 - Ozone
12. Xe - Xenon
13. NO_2 - Nitrogen
14. I_2 - Iodine
15. Rn - Radon

Once students have learned the symbols and formulae above they can examine a table which shows the complete composition of dry air by mass and volume.

Table of Composition of Dry Air

GAS	VOLUME %	MASS%
N_2	78.09	75.51
O_2	20.95	23.15
Ar	0.93	1.28
CO_2	0.03	0.046
Ne	0.0018	0.00125
He	0.00052	0.000072
CH_4	0.00015	0.000094
Kr	0.0001	0.00029
N_2O	0.00005	0.000089
H_2	0.00005	0.0000035
O_3	0.00004	0.000007
Xe	0.000008	0.000036
NO_2	0.0000001	0.0000002

AMOUNT OF GASES IN DRY AIR

(Percentage by volume)

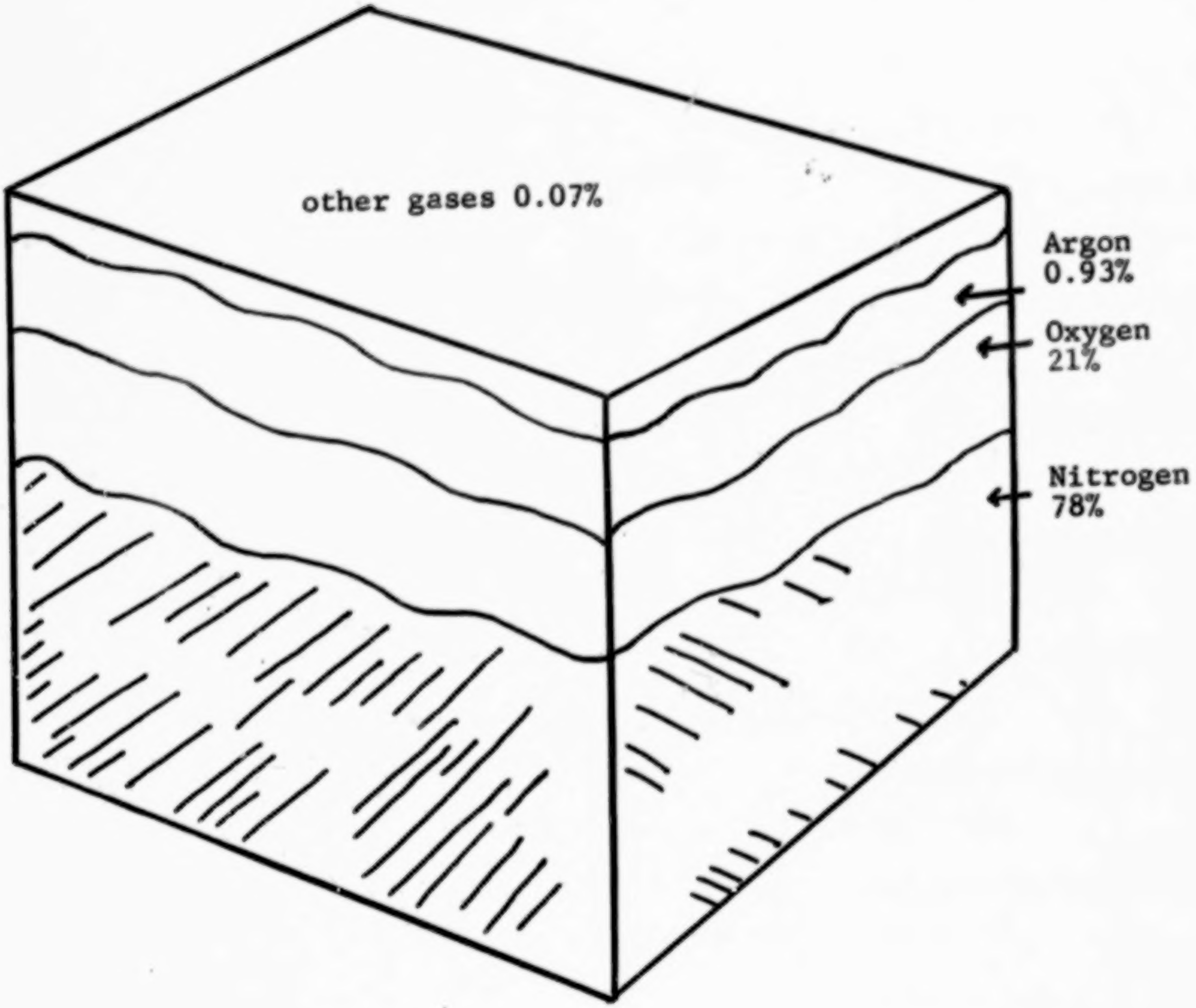

other gases 0.07%
Argon 0.93%
Oxygen 21%
Nitrogen 78%

Diagram shows the per cent composition of the atmosphere by volume.

There are many other aspects to be considered when dealing with our great ocean of air. These are things such as weight, resistance, pressure, air movement, and compression.

How Does Pressure Work?

Since we live at the bottom of the ocean of air which extends upward 1000 miles, we have the weight of the whole column of air above us, pressing down upon us.

When we make measurements of air pressure at different altitudes, we find that the air pressure becomes less and less the higher we go. The reason for this is that the higher one ascends, the shorter the column of air tends to be, notwithstanding the face that the greatest mass of the earth's air is within a zone extending only 3 1/2 miles above sea level.

Properties and Uses of the Most Prominent Gases In the Atmosphere

1. Nitrogen is a colorless and odorless gas, which does not support combustion. It can be converted by certain bacteria to the needs of plants; it can form protein foods. Bacterial decay of plants and animals restores nitrogen to the air and soil.

2. Oxygen is a colorless, odorless gas which does support combustion or burning. This gas is essential to all living things.

3. Carbon Dioxide is a colorless and odorless gas that does not support combustion, and will extinguish a flame by excluding the oxygen. Carbon dioxide is produced by plants and animals as a by-product of respiration.

4. Water Vapor or moisture exists in the atmosphere as an invisible gas which is lighter than air. Large bodies of water give moisture to the atmosphere daily through evaporation. The percentage of water vapor in the air varies up to a maximum of about 4 per cent by volume, depending on the location and season.

Rare gases - Most of these gases do not react with anything in normal chemical reactions, and they are said to be chemically inert.

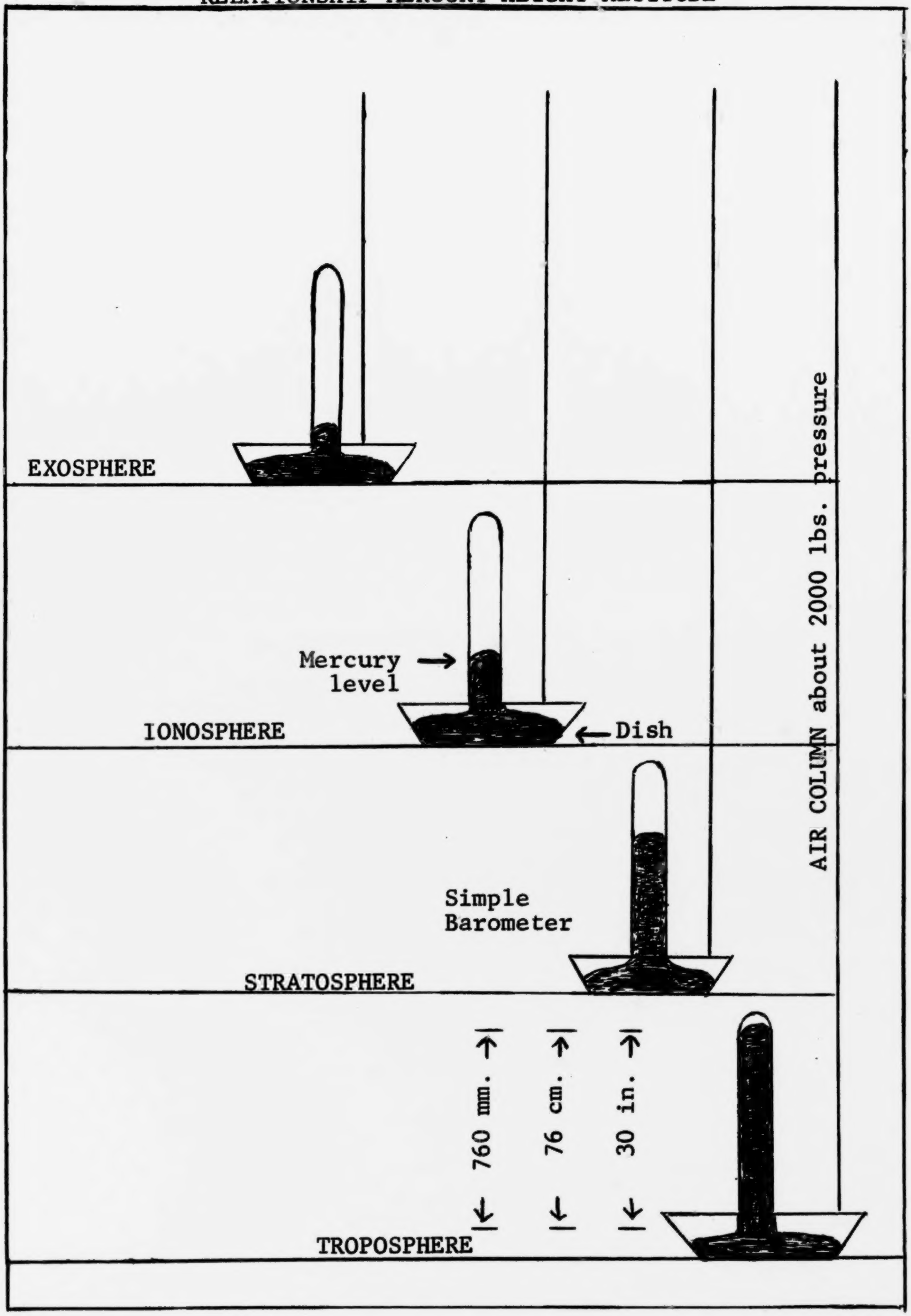
5. Helium is tasteless, odorless, colorless, nonpoisonous, nonflammable, and generally never takes part in a normal chemical reaction.

6. Neon is obtained from liquid air and is often used in laboratories where inert atmospheres are required.

7. Argon is the most abundant rare gas in the atmosphere. It constitutes about one per cent of the atmosphere, and is generally used in the manufacture of high grade electric lamps, and in commercial production of electric bulbs.

8. Krypton is a rare gas which, when used in a fluorescent lamp, produces a greenish-yellow light that will penetrate very dense fog. For this reason it is used in the production of light for sky lighting at night around and above air fields.

RELATIONSHIP MERCURY-HEIGHT-ALTITUDE


EXOSPHERE
Mercury level
IONOSPHERE
Dish
Simple Barometer
STRATOSPHERE
760 mm.
76 cm.
30 in.
TROPOSPHERE
AIR COLUMN about 2000 lbs. pressure

AIR PRESSURE PER SQUARE INCH

ALTITUDE	POUNDS
50,000 feet	1.6
40,000 feet	2.7
30,000 feet	4.3
20,000 feet	6.4
10,000 feet	10.2
Sea Level	14.7

This table shows the change in atmospheric pressure as we proceed from sea level to distances of 50,000 feet above sea level.

Unlike water, air is highly compressible and it weighs about a billion times as much at the bottom of the atmosphere as it weighs at the top of the great ocean of air.

Color Production in Electric Fields

Neon produces red shades depending upon the colors of glass tubing used to envelope the gas. Varying mixtures of neon, argon, and mercury produces colors from green to blue. Helium produces a yellow color. This may account for the presence of auroras in the earth's upper atmosphere.

Since we have a basic knowledge of the nature of gases in the atmosphere, we can now discuss in more detail the structure of the atmosphere itself.

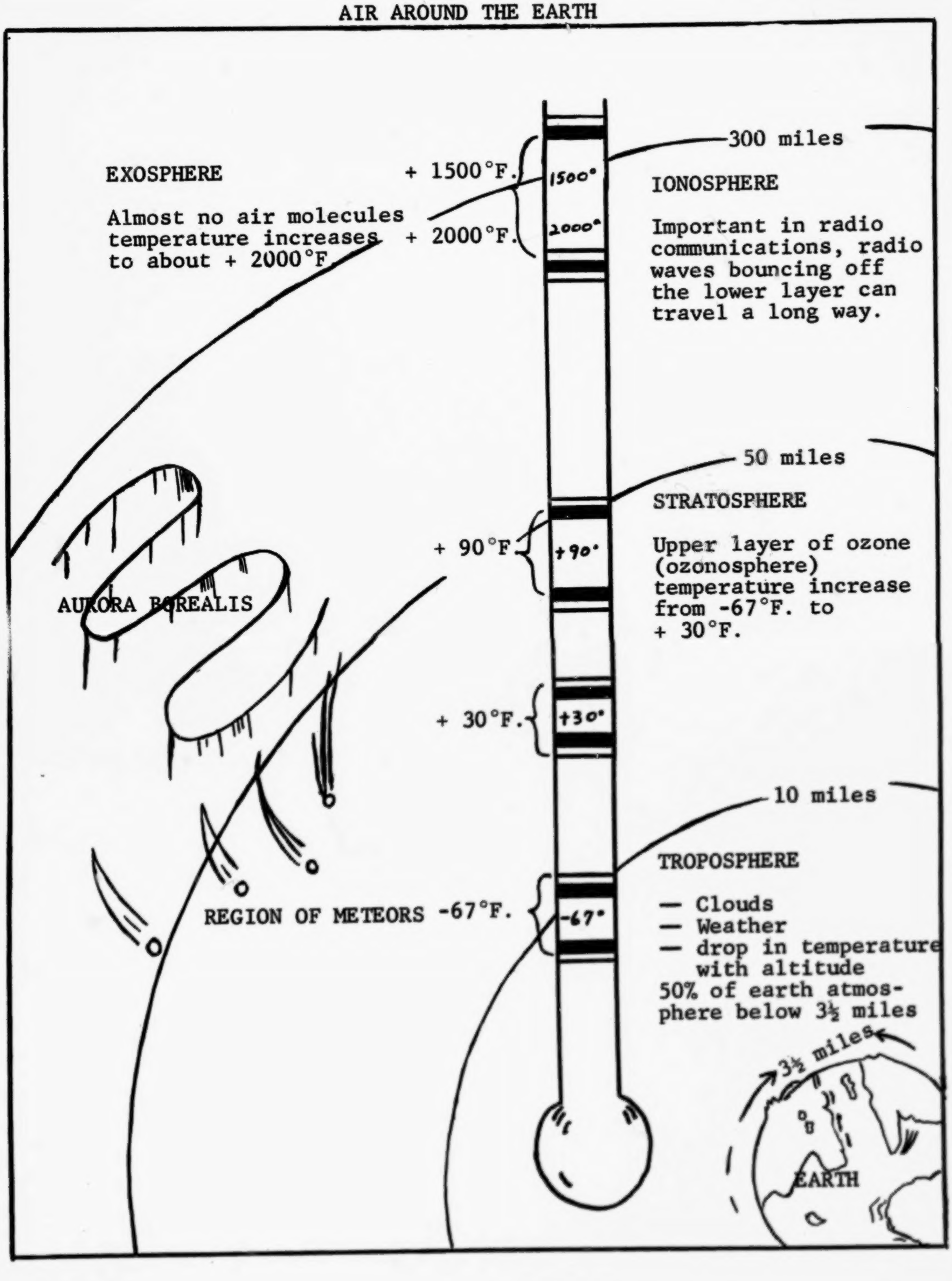
The Earth's Atmosphere and Its Major Subdivisions

The earth's atmosphere is divided into four main layers in the following order: the troposphere, the stratosphere, the ionosphere and the exosphere. There are subdivisions to these principal layers or divisions.

4.1 The Troposphere

The troposphere may be defined as that layer of the earth's atmosphere which is closest to the earth's surface (air) where practically all weather activity takes place. This atmospheric zone begins at the earth's surface and ranges in height from five to eleven miles, depending on the latitude. A five mile height would exist at the North and South poles, while at the equator the zone may be from ten to eleven miles in height. This difference in range is due to the more intense heat in the air (supplied by the sun) near the equator, which causes warm air masses

AIR AROUND THE EARTH


300 miles
EXOSPHERE
+ 1500°F.
1500°
Almost no air molecules temperature increases to about + 2000°F.
+ 2000°F.
2000°
IONOSPHERE
Important in radio communications, radio waves bouncing off the lower layer can travel a long way.
50 miles
STRATOSPHERE
+ 90°F.
+90°
Upper layer of ozone (ozonosphere) temperature increase from -67°F. to + 30°F.
AURORA BOREALIS
+ 30°F.
+30°
10 miles
TROPOSPHERE
REGION OF METEORS -67°F.
-67°
— Clouds
— Weather
— drop in temperature with altitude
50% of earth atmosphere below 3½ miles
3½ miles
EARTH

to rise higher at this point. These warm air masses are directly responsible for our major wind belts on earth. At the poles, however, there is less warm air which causes the cloud formation at the Arctic and Antarctic to be leaden and low.

If one were to ascend in a balloon or airplane, he would find that the temperature of the troposphere decreases at a rate of about 3.3° F. every 1,000 feet, until it reaches -55° F. The constant change or drop in the temperature is highly characteristic of the troposphere.

4.2 The Tropopause

This is the zone where the troposphere ends, and is the lower boundary of the cold, clear stratosphere above it. Its height varies, depending on the air temperature between it and the earth. The height depends on the latitude as well as the temperature between it and the earth. The temperatures and pressures of this zone are very similar to those of the upper troposphere and lower layers of the stratosphere; the temperature averages about -70° F.

4.3 The Stratosphere

This is the layer of the atmosphere just above the tropopause. It extends to a height of about 50 miles and has an average temperature of 70° below zero. The temperature is fairly constant, however, there is a warm zone at an altitude from 25 to 40 miles. This warm layer is due to the presence of Ozone. Ozone is a form of heavy oxygen, having three atoms per molecule instead of the customary two. It has the property of being a good absorber of ultraviolet radiation from the sun. In absorbing this radiation, the Ozone heats up and thus produces the warm layer. The lower part of the stratosphere is called the isosphere, or constant temperature region, and is above the region of storms and snow. It also has practically no convection, or rising air currents. The winds are strong, but usually steady and parallel. For these reasons, aircraft pilots like to fly in the lower stratosphere. If we should measure the atmospheric pressure as we pass vertically through the stratosphere, we would find that it decreases steadily until at the upper level it would be less than one-ten-thousandth of its value at sea level. The top of the inversion layer in the upper stratosphere is called the stratopause.

4.4 What additional belts would I encounter if it were possible for me to move vertically outward more than 40 miles?

A. The Ionosphere

The region of the atmosphere that extends upward from the ozone layer is frequently called the mesosphere with the uppermost region being the stratopause. Here the air undergoes a very distinct change, for it marks the beginning of the ionosphere. Radiation and high speed charge particles from the sun and space and bombard molecules of oxygen and nitrogen, breaking them up into individual atoms and even ionize many of them. The ionosphere begins at an altitude of about 45 miles and extends to an altitude of 200 miles. It contains at least four fluctuating layers where the ionized gas is concentrated. These ionized layers reflect radio waves and make long-range radio communication possible.

B. The Exosphere

The fourth zone of the atmosphere, the exosphere, starts at an altitude of 400 to 500 miles above the surface of the earth. In this region the ions and individual molecules move outward toward interplanetary space. A few of the lighter ones are able to escape the earth's gravitational field, but the majority of them are restrained by the field. For this reason the exosphere is often referred to as the fountain layer of the earth's atmosphere.

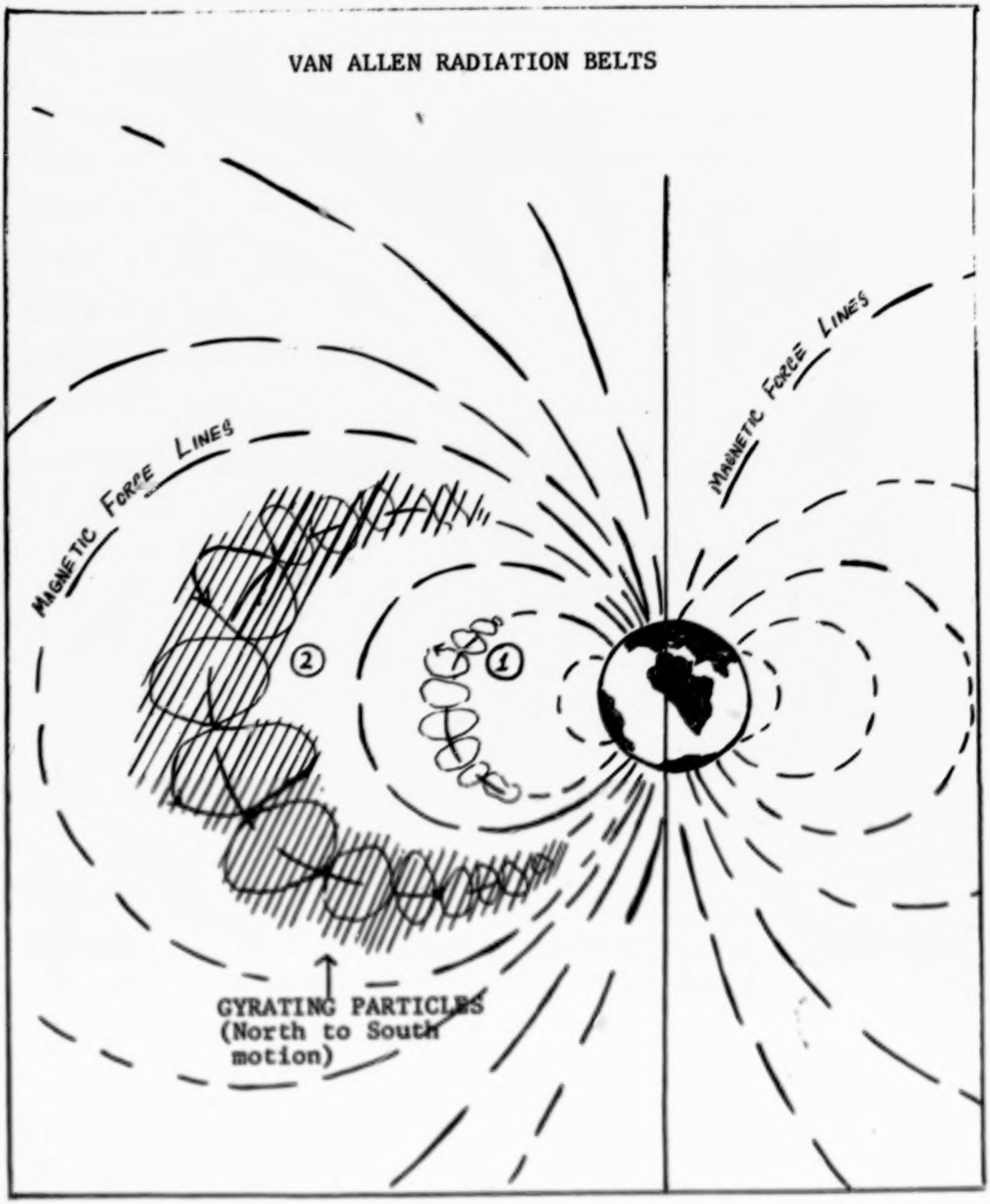
C. The Van Allen Radiation Layer

Probably the most important discovery made by early artificial satellites was a zone of rapidly moving charged particles high above the surface of the earth. The Army satellite, Explorer I, was the first satellite to detect the inner part of this zone. The radiation detection experiments on Explorer I was under the supervision of

Dr. James A. Van Allen, and thus the radiation zone is called the Van Allen Layer, in his honor.

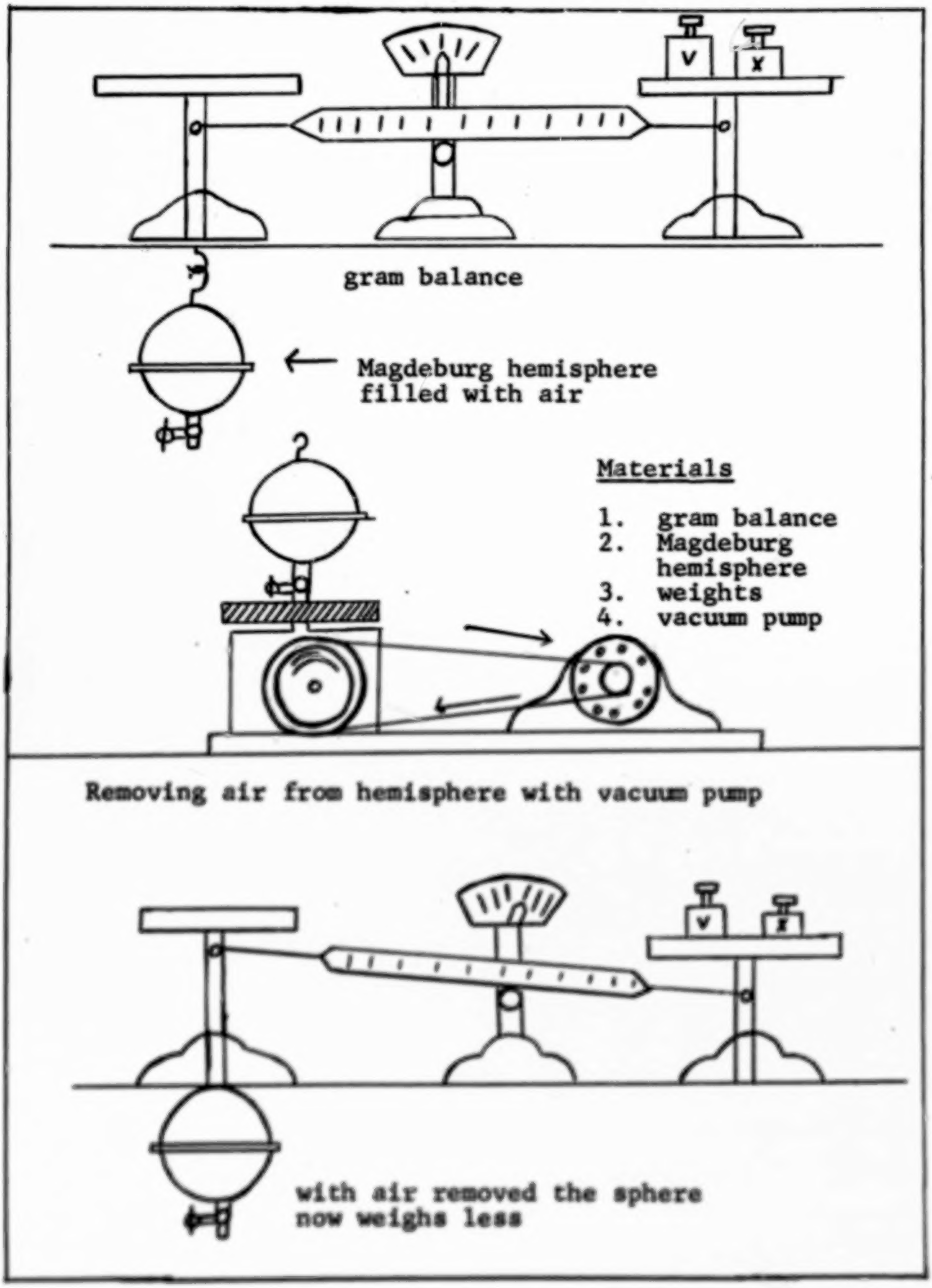
The Van Allen Layer consists of highly energetic charged particles trapped in the earth's magnetic field. Physicists believe that most of these particles are electrons, although the inner portion seems to have protons as well. The possible origin of these particles seem to result from the solar flares and wind from the sun. It is believed that the sun, during intense solar storms, sends out flares of highly charged particles for at least a million miles from the sun's surface. The solar winds force these particles outward into the earth's magnetic field, where they are trapped and finally remain. The particles oscillate or gyrate back and forth from the northern to the southern hemisphere along magnetic lines of force. This results in two doughnut-shaped configurations around the earth.

The radiation belt has its greatest intensity in two zones; one at about 2000 and the other at about 10,000 miles above the earth's surface. The radiation layer seems to disappear completely at the height of 40,000 miles.


VAN ALLEN RADIATION BELTS
MAGNETIC FORCE LINES
MAGNETIC FORCE LINES
②
①
GYRATING PARTICLES
(North to South
motion)

Lines of force of the earth's magnetic field trap electrically charged particles from the sun in the outer portion of the Van Allen radiation zone (hatching.) The spiral represents the portion of a trapped particle gyrating back and forth, from the North to the South pole. Inner belt (1) and outer belt (2).

EXPERIMENT TO PROVE AIR HAS WEIGHT


V
X
gram balance
Magdeburg hemisphere filled with air
Removing air from hemisphere with vacuum pump
V
X
with air removed the sphere now weighs less

Materials

1. gram balance
2. Magdeburg hemisphere
3. weights
4. vacuum pump

EVALUATION

1. Why does man need knowledge about the atmosphere about him?
2. What are some of the ways men have studied the atmosphere about him?
3. What is the atmosphere? Name its four main layers.
4. Where is the tropopause?
5. What is the tropopause?
6. In what region does most weather occur in the earth's atmosphere?
7. What is the temperature range in the troposphere?
8. How high up is the stratosphere?
9. What is the temperature range in the stratosphere?
10. What is the composition of the upper range of the earth's atmosphere?
11. Is the composition of the top of the atmosphere like the composition of the atmosphere directly above the earth?
12. Where is the mesosphere located in the earth's atmosphere?
13. Where is the mesopause located?
14. What kind of condition exists in the mesosphere?
15. What are some events which occur in the ionosphere?
16. What are Van Allen Radiation belts?
17. How do the Van Allen Radiation belts effect space travel?
18. How do we account for the Van Allen Belts?
19. What is the principle behind the "Auroras."
20. Name some spectacular occurrences of the Ionosphere.

CHAPTER V

What are the environmental factors my experimental aircraft will encounter as it moves to different geographic locations in the Troposphere, such as:

5.1 Movement North and South of the equator to different zones established by the Earth's tilt:

If one observes the motion of the earth over a long interval of time, it is found that the earth is going through two main motions at once. The earth revolves eastward around the sun once in a year, and rotates meanwhile on its axis once every 24 hours. If the orbit of the earth around the sun were a circle, then the sun would always have the same diameter as viewed from the earth, because its distance from the earth would be constant. If the apparent diameter of the sun is measured in January then again in July it is found that the diameter is greater in January. The difference between the two measurements is about one-thirtieth of the average diameter. This means that the earth's orbit about the sun is an ellipse, and it is about 3 per cent closer in January than it is in July. The earth's distance from the sun varies from 91,300,000 miles in January to 94,500,000 in July. The average distance is 92,900,000 miles.

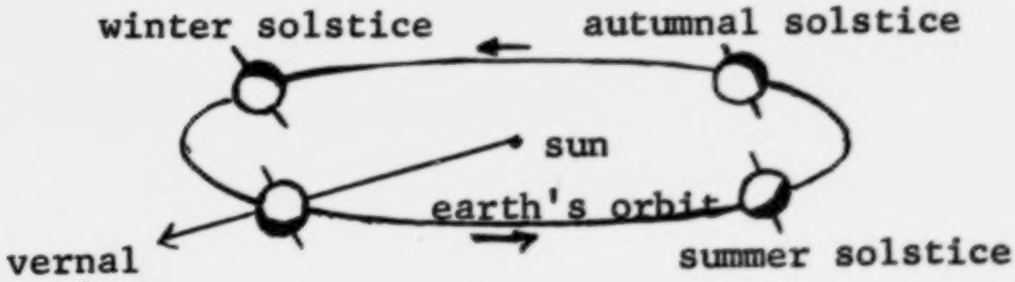
Thus we see that the distance from the sun is not responsible for our seasons, because if that were true we would have our hottest weather in the northern hemisphere in January. We all realize that the rotation of the earth is responsible for day and night, but what causes the seasons?

There are three factors involved in producing a change in the seasons:

1. The revolution of the earth about the sun.
2. The axis of the earth is tilted 23 1/2° to the plane of its orbit.
3. Parallelism of the axis.

The last two factors are somewhat related, therefore it is easiest to discuss the two together. The ecliptic and the celestial equator are inclined to each other by approximately 23 1/2°. The ecliptic is defined as the plane containing the earth's orbit, and the celestial equator indicates the plane of the earth's equator, thus we can say that their respective planes are inclined at an angle of 23 1/2°. In other words the earth does not "sit upright" as it spins in its orbit about the sun, but spins about an axis that makes an angle of 23 1/2° from the perpendicular to the plane in which it revolves. Most of us have seen globes of the earth mounted with the earth's axis tilted from the vertical, instead of having the axis aligned with the vertical.

During one revolution of the earth around the sun its axis always points to the same fixed point in space, namely the north celestial pole. Polaris, or the "North Star," is the closest bright star to this point. This is called parallelism of the axis. Now because the earth's axis is tilted with respect to the plane of its orbit, the Northern Hemisphere is inclined toward the sun for six months. This results in the seasons and the accompanying phenomena such as longer days, high angle of the sun's rays, and higher daily temperature in the Northern Hemisphere. In the winter, the Northern Hemisphere is tilted away from the sun, so the daily duration of sunshine is shorter for us and the sun's rays come down more slanting. In simple terms, the weather is warmer in the summer because the sun shines for a longer time each day and the rays come more nearly vertically downward. At the equator all seasons are much the same. Every day of the year there are 12 hours of sunshine.



The seasons are caused by the inclination of the earth's axis to the plane of its orbit.

Climate Zones

A climate zone is a portion of the earth bounded by parallels of latitude and characterized by a distinctive climate. The position and width of these zones are determined also by the inclination of the earth's axis to the plane of its orbit.

The torrid or tropical zone extends from the equator to the tropics of Cancer and Capricorn at 23 1/2° north and south latitudes, respectively. In the torrid zone the midday sun is high above the horizon throughout the year. Consequently perpetual warmth bathes the torrid zone. Also in the torrid zone, the air flows quite steadily, mainly from east to west. This flow of air, the trade winds, provides ventilation in a climate that would otherwise be uncomfortably warm and humid. The trade winds of each hemisphere move gently toward the equatorial region, where compensating upward currents cool to provide extensive cloudiness and heavy rainfall in the moisture-laden air.

The two frigid zones extend from the poles to the Arctic and Antarctic circles at 66 1/2° north and south latitudes. In the frigid zones the cooling of the atmosphere is larger than the meager heating supplied by the sun, which is never far above the horizon and is altogether absent much of the winter. Consequently bitter cold in the zones is interrupted only by a brief, and mild summer. Within the frigid zones the climate is relatively calm, though the effects of storms from the temperate latitude are felt intermittently. On ice sheets of Antarctica and Greenland, temperatures remain below freezing all year and sink in winter to the world's lowest levels.

Between the frigid and torrid zones lie the north and south temperate zones. Over the temperate zones the rotation of the earth about its axis becomes effective in creating a different climate. The climate in which the most highly developed civilizations have grown, is a changeable environment in which frequent storms insure abundant rainfall. In the northern temperate zone, dryness and extremes of summer heat and winter cold characterize the interior portions of Asia and of North America. Southeast Asia experiences the world's heaviest rainfall as the steady summer monsoon wind from the adjacent ocean is forced to ascend the massive mountain barriers of that region.

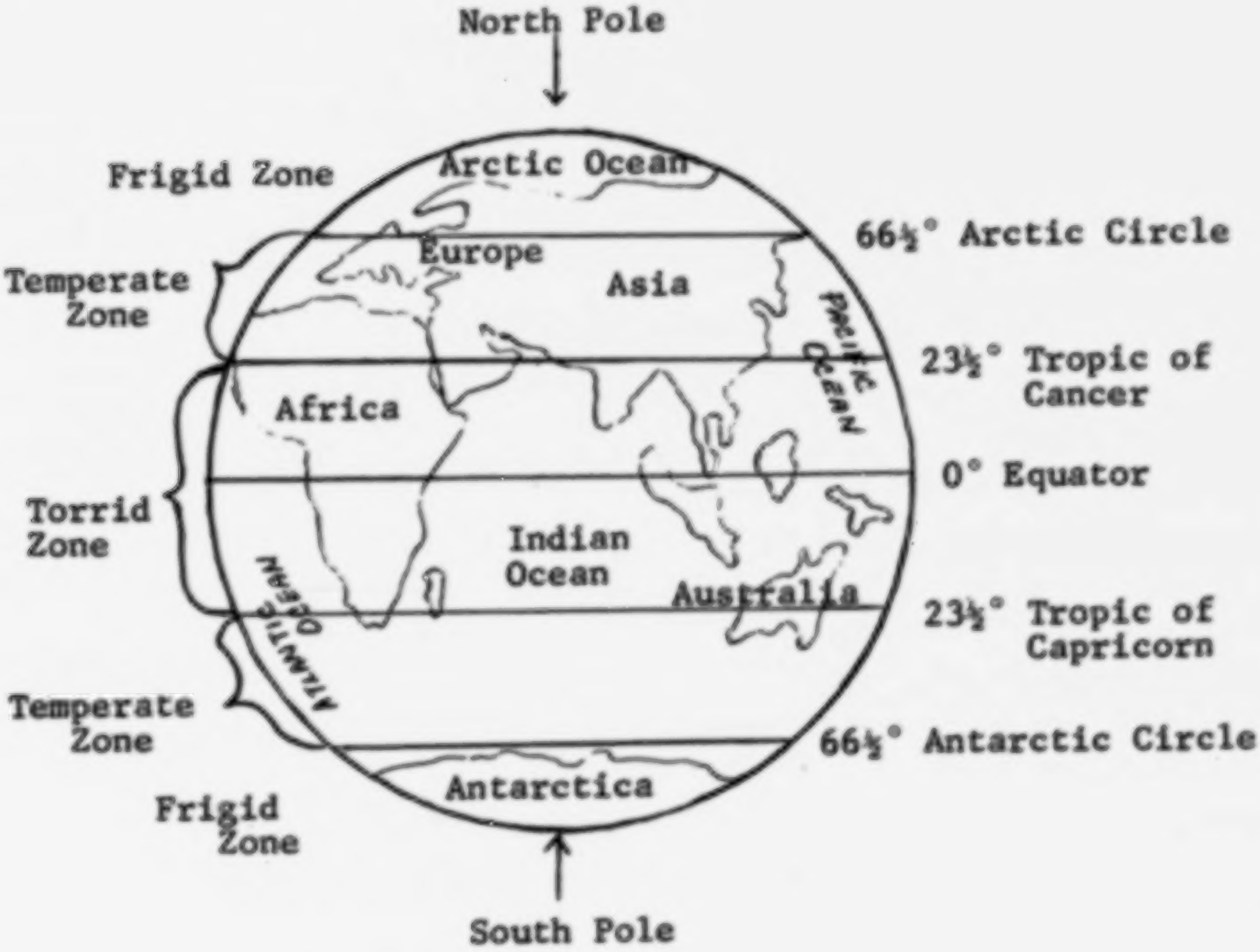
In dealing with the different zones a person should realize what part of the earth is covered by these zones. The torrid zone covers 40 per cent, the frigid zone 8 per cent, and the temperate zone covering 52 per cent of the earth's area.

Brief Outline of the Zones

Frigid Zones--The sun may not rise above the horizon for 24 consecutive hours during parts of the year, and may not pass below the horizon for 24 consecutive hours during opposite seasons. The north and south frigid zones extend 23 1/2° from the poles.

Temperate Zone--The sun never passes directly overhead at noon, nor does it ever fail to rise above the horizon. The temperature in the temperate zone has an average of 50° F. four to five months of the year.

Torrid Zone--The sun passes directly overhead (at noon) at least one day in each year, and the temperature averages above 68° F. for the coldest month.


North Pole
Frigid Zone
Arctic Ocean
66½° Arctic Circle
Temperate Zone
Europe
Asia
Pacific Ocean
23½° Tropic of Cancer
Africa
0° Equator
Torrid Zone
Indian Ocean
Atlantic Ocean
Australia
23½° Tropic of Capricorn
Temperate Zone
66½° Antarctic Circle
Antarctica
Frigid Zone
South Pole

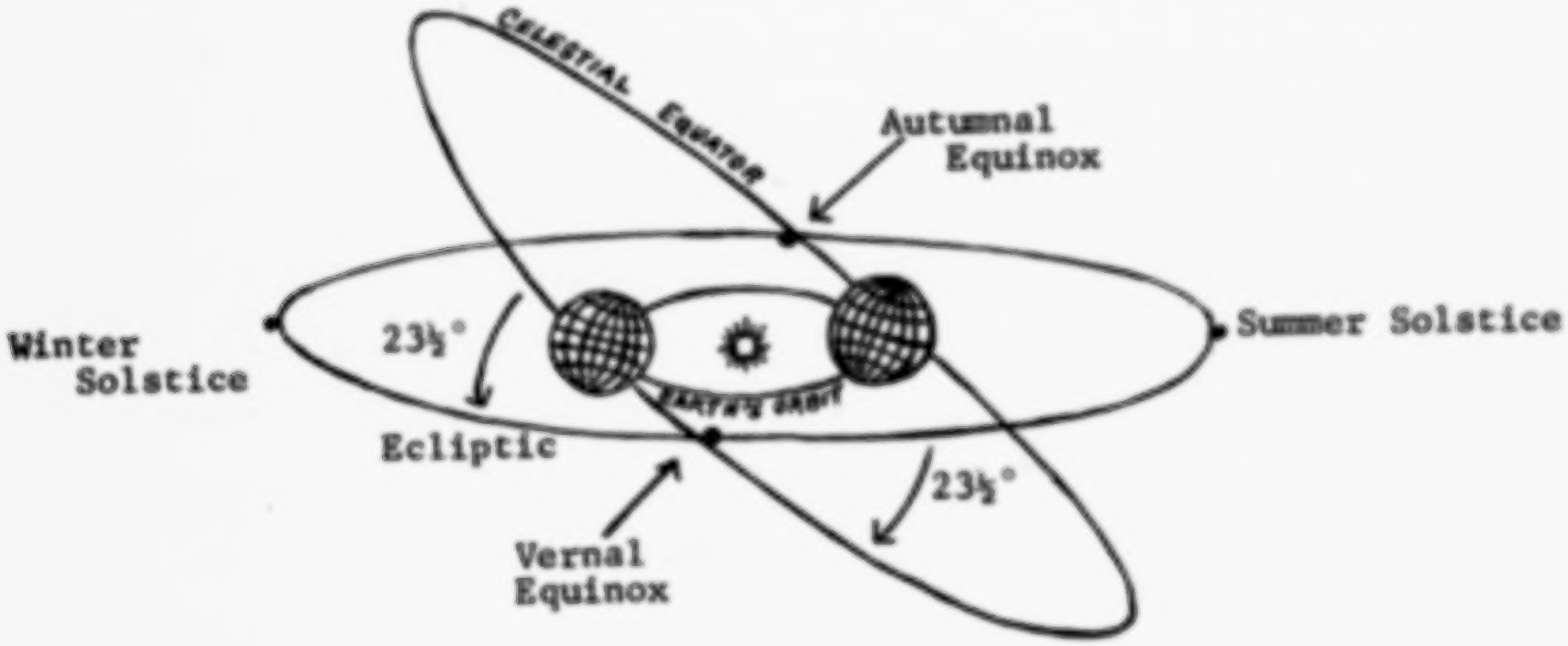
The Earth's Climate Zones

5.2 Movements North and South of the equator at different seasons of the year.

A. What are the equinoxes?

We have seen that the plane of the celestial equator is determined by the earth's terrestrial equator which in turn is determined by the earth's rotation. A motion of the earth also defines a second important plane, the plane of the earth's orbit, which is determined by the earth's revolution. This plane intersects the celestial sphere in a circle called the ecliptic. The simplest way to define the ecliptic is to say that it is the sun's apparent path around the earth.

Thus as the sun apparently moves around the celestial sphere its path crosses the celestial equator at two points. The point and the time the sun crosses the celestial equator moving northward are both called the vernal equinox; called "equinox" (from the Latin meaning equal night) because at such times day and night are equal in length. This occurs on or about March 21 and it marks the beginning of spring. One-quarter of a revolution later the sun will be at its northernmost point on the ecliptic, a point and time (June 22) known as the summer solstice. The summer solstice officially marks the beginning of summer in the Northern Hemisphere. Six months after the sun reaches the vernal equinox, it crosses the celestial equator a second time. This time and point of crossing are called the autumnal equinox. The autumnal equinox marks the beginning of the seasons when the night is longer than the day, and also the official beginning of autumn (September 23). In another three months (December 22) the sun will be at its southernmost point on the ecliptic and winter begins. This is known as the winter solstice.

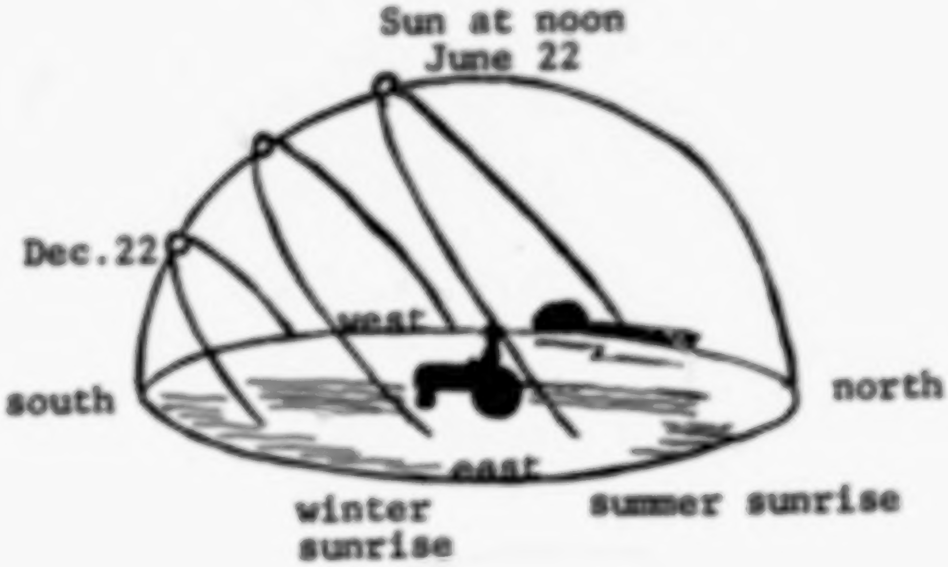

Celestial Equator
Autumnal Equinox
Winter Solstice
23½°
Summer Solstice
Earth's Orbit
Ecliptic
23½°
Vernal Equinox

THE CELESTIAL EQUATOR IS INCLINED
TO THE ECLIPTIC

B. What causes the lag of the seasons?

Summer in our northern latitudes begins about June 22, when the sun arrives at the summer solstice. At this time the sun climbs highest in the sky and the duration of sunshine is longest on that day. Yet, the hottest part of the summer is likely to be delayed several weeks.

Why does the peak of the summer come after the time of the solstice? As the sun goes south, its rays bring less heat to our part of the world. Summer does not reach its highest point until the rate of heating is reduced to the rate of cooling. Likewise, our winter weather is likely to be more severe several weeks after the time of the winter solstice. About December 22 the temperature continues to fall generally until the amount of heat we receive from the sun becomes as great as the daily loss.



Paths of the Sun in the Summer and Winter

Laboratory Experiences

Introduction: The earth is tilted which effects our seasons.

Problem: What proof do we have that the earth is tilted?

Materials: Globe, slide projector, and screen wire

Procedure:

1. Cut a piece of screen so that it will fit a standard 2"x2" slide. Put it in the projector.
2. Turn the lamp on the projector so that it will be focusing the screen wire on the globe.
3. Place the globe so that it is inclined away from the projector, toward the projector and at the right angles to the projector. This will show the earth's positions relative to the sun for various seasons.
4. Note where the light from the projector strikes the globe most directly.

Conclusion:

1. When are the squares made by the screen wire the smallest?
2. When are the squares larger?
3. Why are summers in the northern hemisphere much warmer than the winter?
4. If the earth were not inclined how would this effect our seasons?

(Laboratory Experience for Junior High School Science, 1966, Arlington County Public Schools, Arlington, Virginia)

5.3 Variations in weather caused by:

A. General circulation of air

Why does the direction of wind deflection differ in the northern and southern hemisphere? The causes of the wind belts are not simple. Scientists themselves are not yet sure of all the causes.

The rotation of the earth plays a vital role in wind direction. If the earth were standing still, the cold polar air would move toward the equator, pushing up the expanding hot air. The winds would tend to meet head-on and would not be deflected.

Since the earth is rotating, it moves under the winds. It has been shown by Ferrel's Law that anything moving freely over the surface of the rotating earth will tend to be turned to the right in the northern hemisphere and to the left in the southern hemisphere. This will be discussed in greater detail in the next section.

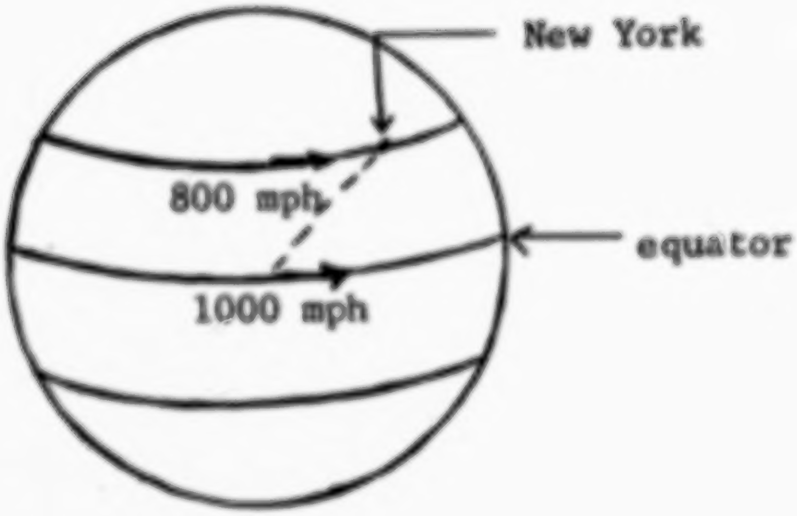
Therefore, if a person starts walking from north to south, but turns a little to the right at each step, you will presently find yourself walking from east to west. Also, if you walk from south to north, but turn to the left, you will find yourself walking from east to west.

To summarize, the atmosphere circulates between the poles and the equator. The unequal heating of the earth's surface causes this circulation. The movement of the atmosphere is modified greatly and complicated by the rotation of the earth. The atmosphere is also greatly modified by irregular distribution of land, water, and differences of land elevation.

B. Coriolis forces

The speed of the earth's rotation changes as one goes from the equator to the poles. At the equator the speed is slightly greater than 1000 miles per hour; in the latitude of New York it is reduced to 800 miles per hour; it is 500 miles per hour in southern Alaska. This reduction of speed with increasing latitude continues until at the poles it is zero.

To better understand one of the effects of the earth's rotation, consider a missile fired from the equator directly at New York. The missile will be given a certain initial velocity northward, and because of the rotation of the earth, it will also be given an eastward velocity of 1000 miles per hour (since it is fired from the equator). The target (New York) will also have an eastward velocity but it is only 800 miles per hour. Thus in firing the missile, if the rotation of the earth is neglected the missile will hit east, or to the right, of New York. Thus one could say that the missile has been deflected to the right. See diagram on the following page.



Deflection of Moving Object in the Northern Hemisphere

Consider an air current moving northward in the northern hemisphere. It is going from a latitude of faster rotation to one of slower rotation, therefore it will forge ahead and be deflected to the right because of the earth's rotation. If the air current is moving toward the equator instead, it is going from a place of slower to one of faster rotation, and as viewed by one facing toward the equator it will be deflected toward the right. It is easy to see that a current in the southern hemisphere will be deflected to the left. Thus we can say that moving objects are deflected to the right in the northern hemisphere and to the left in the southern hemisphere due to the earth's rotation. This deflection is known as the Coriolis force or the Coriolis acceleration.

C. Wind Belts

As pointed out earlier, near the surface of the earth there is a flow of air between the equator and the poles. The Coriolis force has a strong influence on the winds thus produced. If the earth were not rotating the winds would blow straight north and south, but the rotation and corresponding deflection is such as to produce a series of bands around the earth. These wind belts will be discussed, neglecting the irregularities produced by mountain ranges and large bodies of water.

1. Doldrums

The doldrums is a belt lying roughly between 5° north and south latitude. The primary driving force of the circulation is the lifting action of the heated air near the equator. This lifting action creates a general low pressure region, produces calms, and weak undependable winds. The doldrums were feared in the days of sailing ships, for a vessel which entered it might be becalmed for days or even weeks.

2. Trade Winds

At a latitude of around 30° the warm air that was heated at the equator has cooled sufficiently to begin to sink toward the earth's surface. This descending air forms a belt of high pressure known as the horse latitudes. The winds here are very similar to those of the doldrums...weak and undependable. The name "horse latitudes" was supposedly derived from the fact that vessels carrying horses to the New World were frequently becalmed in these regions of the Atlantic. As supplies became scarce, it was necessary to throw the horses overboard.

As the air descends toward the surface of the earth a portion of it flows north and a portion flows to the south. The winds moving back toward the equator in both hemispheres are known as the trade winds. The Coriolis force deflects the trades to the right in the northern hemisphere and they are called the northeast trades. In the southern hemisphere they are deflected to the left and become the southeast trades. Both regions are noted for their steady prevailing winds.

3. Prevailing Westerlies

The part of the descending air at the horse latitudes that flows toward the poles is deflected and forms the belts known as the westerlies. They extend roughly from 40° to 65° north and south latitudes. They are characterized by alternate stormy and fine weather, and the winds are much less steady than the trades. Almost all of the United States, Alaska, Canada, and most of Europe are within this belt.

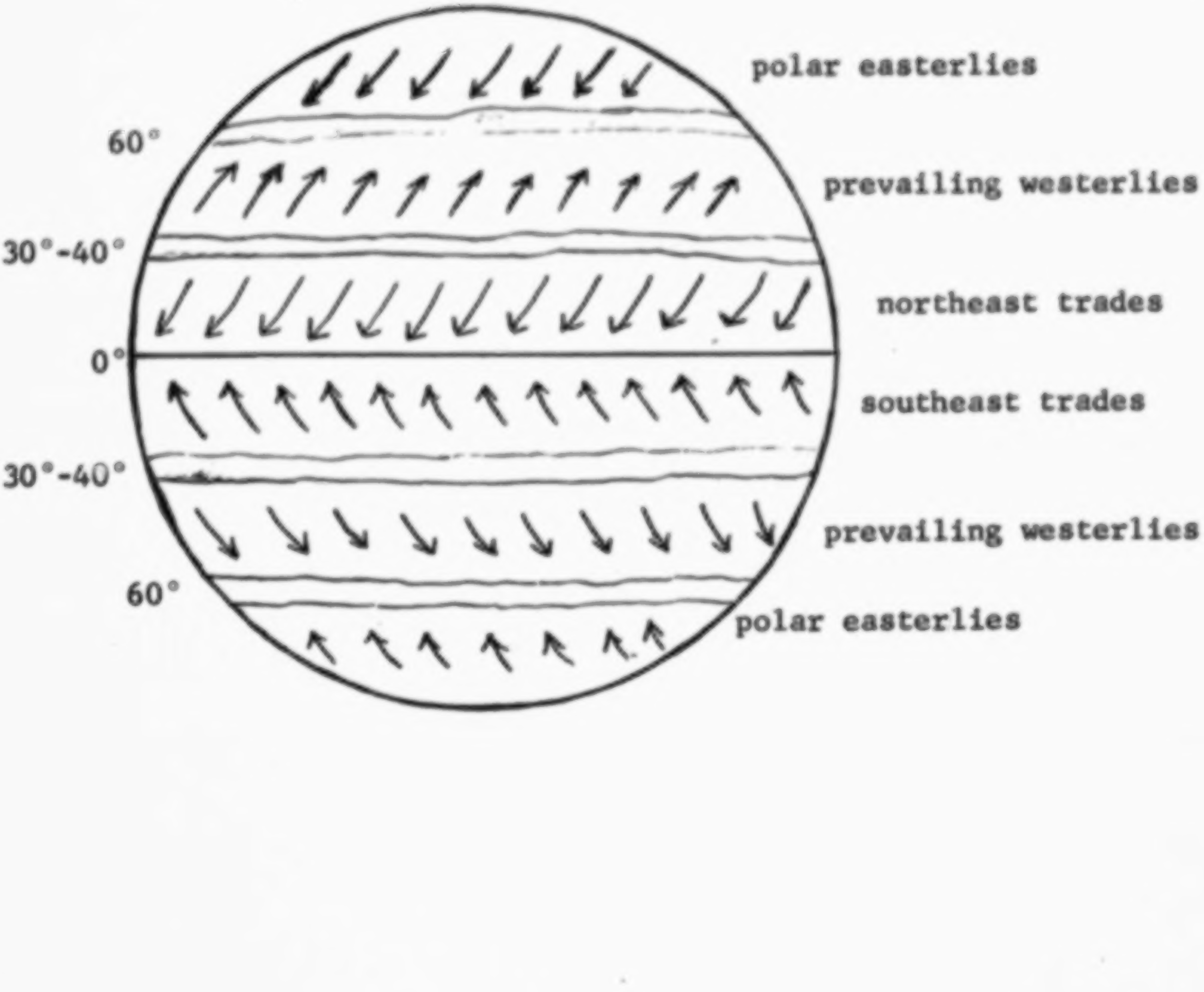
4. Sub-polar Lows

At a latitude of around 65° is another belt of low pressure known as the sub-polar lows. These low pressure regions are produced by the lifting of the warm equatorial air by cold polar air moving toward the equator.

5. Polar Easterlies

The polar easterlies are the belts near the poles due to the general movement of the cold air masses toward the equator. The winds produced by this movement are deflected to the right in the northern hemisphere and to the left in the southern hemisphere. These winds are extremely weak because of the low temperatures at the poles. Not a great deal is known about the winds in the region of the poles, but extensive studies are being made at the present time. (See next page)

WIND BELTS


polar easterlies
60°
prevailing westerlies
30°-40°
northeast trades
0°
southeast trades
30°-40°
prevailing westerlies
60°
polar easterlies

D. Moisture Content of Air

Water vapor is thought to be one of the important constituents of the air as far as weather and most meteorological processes are concerned because it condenses as clouds, fog, rain, hail, sleet, dew and snow. This water vapor absorbs some of the radiation for the sun and a large fraction of the heat radiated by the earth. This absorbing process keeps the earth at a moderate temperature both night and day. The amount of moisture in the air varies considerably according to the locations, seasons, temperature, winds and other conditions.

At the earth's surface the maximum amount of water vapor is about 2.6 per cent of the volume of the air at the equator, 0.9 per cent at latitude 50°, and 0.2 per cent at 70° latitude.

Some important terms that will help one understand the moisture content of the air are as follows:

Humidity - The amount of water vapor in the air.

Relative Humidity - Ratio between water vapor actually in the air and the maximum possible amount at a given temperature.

Dew Point - That temperature to which air must be cooled in order for the water vapor present in the air to condense and change back to the liquid state.

1. Clouds

Clouds are usually produced by the cooling of a body or mass of air. They are the result of a drop in the temperature of the air with the condensation of its water vapor in the form of tiny droplets. Clouds made up of water droplets are high fogs. Clouds are usually formed in a particular region of the atmosphere mainly by the upward motion of air masses. When this air rises it expands because the pressure is decreased and the air becomes cooler. A downward motion of air has the opposite effect, because the pressure increases with the low altitude which compresses the air, causing it to be heated.

It is now thought that cooling is not the only requirement for the formation of a cloud. Even if air is saturated with water vapor, cloud droplets usually will not form unless some kind of microscopic particles are present upon which the water may collect as it condenses.

An English chemist named Luke Howard devised the first system for naming and classifying cloud types. This was done in 1803, and since then his system has been revised slightly; but it forms the basis for our present method of naming the cloud types. The main forms of clouds are cirrus, cumulus, nimbus and stratus.

Cirrus (meaning "curl") Clouds are thin, feathery, or tufted white clouds that form high above all other clouds. Because of this great height, they are always composed of ice crystals. All of the "high" family of clouds are of this cirrus type and some of them are found as much as ten miles above the earth's surface.

Cumulus (meaning "heap") Clouds are beautiful thick, fleecy, heaped up masses of white clouds which often float across the summer day sky. They are about a mile above the earth and are formed by vertically rising air currents. Many heavy cumulus clouds often foretell rain. Cumulus clouds increase in size and number when the sun is its warmest in midafternoon; but in the latter part of the day they disappear into the flatness of stratus clouds.

Nimbus (meaning "raincloud") Clouds are dark gray clouds with no definite shape and usually produce precipitation. The lower half of a nimbus cloud is weighted with moisture and this changes into falling raindrops.

Stratus (meaning "spread") Clouds are low, uniform sheets of clouds which form a few hundred feet above the ground. They are thin and fog-like and are usually seen in early morning or late evening, when the air is still.

Clouds may be classified according to height in the following manner:

1. Cirrus
2. Cirrocumulus
3. Cirrostratus
4. Altocumulus
5. Altostratus
6. Stratus
7. Stratocumulus
8. Nimbostratus
9. Cumulus
10. Cumulonimbus

These cloud types are described in the accompanying chart.

TYPES OF CLOUDS

Cloud Name	Height	Description	Remarks
1. Cirrus	High Clouds	Curly, white semi-transparent clouds	Made up of ice crystals that form high above all other clouds.
2. Cirrocumulus	18,000 to	A mass of small lumpy bands of cumulus clouds	Formed at heights above 20,000 ft.
3. Cirrostratus	40,000	A thin white sheet usually of ice crystals. Too thin to obscure sun or moon.	Produce "Halo-Rings" seen around sun or moon.

Cloud Name	Height	Description	Remarks
4. Altocumulus	Intermediate Clouds	Round white or grayish patches, usually arranged in rows and packed closely together	Appear at heights from 8000 to 20,000 ft. may indicate approaching frontal clouds.
5. Altostratus	18,000 ft.	Thick gray-blue fibrous sheet or heavy gray sheet.	Indicates rain, snow or turbulent weather.
6. Stratus	Low Clouds Below 6,000 ft.	Thin, fog-like clouds formed without shape when the air is still.	Usually form only a few hundred feet above the ground in early morning or late evening.
7. Stratocumulus		Layer or series of water-droplet clouds, fluffy and wavy surface.	Drizzle or rain may fall. Range from near the surface to about 6,500 ft. in height.
8. Nimbostratus		Dark gray rain clouds or rather shapeless formation	Low half is heavy with moisture which usually turns in continuous rain or snow.
9. Cumulus	Low to highest level	Beautiful heaped-up masses of billowy, thick white clouds	In mid-afternoon clouds increase in size and number. In evening, they disappear in the flatness of stratus clouds.
10. Cumulonimbus		Cauliflower-shaped clouds, very massive clouds that stretch through all levels	Usually called "thunderheads", heavy showers lightning and thunder storms.

2. Fog

Fog is a result of the water vapor in the air condensing to form tiny droplets of water. As air is cooled it holds less and less water vapor. The temperature at which water droplets form from moist air is known as the dew point.

The first type of fog is called radiation or ground fog. This is caused by the cooling of the earth at night. As the air close to the earth comes in contact with the cool earth it is chilled below its dew point and the condensation of water vapor occurs. This forms on clear nights when the breezes are calm.

Valleys and other low places have the thickest fogs because cool air is more dense than warm air and tends to drift to low places. Fog is also thick in cities because it condenses around the dust particles in the air.

Another type of fog is advection fogs. These form as a result of horizontal movement of warm, moist air over cool surfaces. These fogs are common where there are icebergs, cold seacoasts, snow covered ground and rivers. Warm moist air from the south blows across these cool surfaces and condenses to form fogs.

A third type of fog is an upslope fog. This type fog is formed by the cooling of air as it sweeps up rising slopes such as mountains. This type fog is cooled by the expansion of air as it goes up to low pressure areas.

Steam fogs are formed in polar regions where warm water evaporates into cold air blowing over the surface.

3. Rain

You have had many experiences with rain, sleet, hail, snow, dew and frost. They are all forms of precipitation (the moisture that condenses out of the air when its temperature falls below the dew point). Each form of precipitation is produced under certain special conditions of its own; but all forms are alike in one way; ie. the air must be cooled below the dew point before water vapor will condense to form water droplets or ice crystals.

Water vapor enters the air by evaporation and the temperature of the air affects the amount of water vapor it can hold. Warm air is less dense than cool air and, therefore, rises. As the warm air rises from the earth's surface, it is cooled and its temperature reaches the dew point, or that temperature to which air must be cooled in order for water vapor to change back into a liquid. Condensation is also a process in which water vapor is changed into a liquid.

As air rises, water vapor within it collects around small particles of dust and salt in the process of condensation. (Some salt enters the atmosphere by the action of winds on large bodies of salt water such as oceans). As the air continues to rise, more of the water vapor condenses, forming droplets which at first are usually too small, and frequently evaporate. The air becomes less dense as it rises and the water vapor remaining sticks to the dust particles and begins to form large droplets. The temperature gets colder as the air rises and the rate of condensation is increased. These water droplets grow larger because of the continuous condensation and may eventually fall to the earth in the form of rain from a cloud, but at other times they do not. If the air in a cloud is cooled still further, even more water vapor condenses. Some of it condenses on the water droplets already in the cloud and makes them larger. Moving air also jostles the droplets around, and they bump into each other. When two of them touch they run together and form a bigger drop of water. They get so big they can no longer float in the air, thereby falling to the ground as raindrops.

Intensity of rainfall varies from zero up to several inches per hour. Measurement of rainfall can be made by several types of rain gauges. One type of gauge consists of a widemouthed funnel which catches the rain and empties it into a cylindrical container below. The mouth of the funnel is exactly ten times larger in diameter, so that 1/10 inch of rain will fill the container to a depth of one inch. This magnification of the actual rainfall makes it possible to measure the fall very accurately with a marked stick which is dipped into the container.

How would you compensate for increase in volume of water caused by submersion of the marked stick?

Rain gauges can also be used to measure snowfall. The collected snow is melted and the water is weighed to determine its rain equivalent.

4. Hail and Sleet

The drops of rain sometimes fall through a layer of air near the surface of the earth where the temperature is below freezing. Then the drops freeze and fall to the earth as sleet. Therefore sleet is just frozen rain. Hail usually forms during summer thunderstorms when there are strong upward currents of air inside cumulus clouds. Small bits of ice form in the cold air high above the earth. When these fall through warmer moist air, they are covered with water. As they continue to move downward through successive layers of moist air and cold air, additional layers of ice form over the preceding layer, until the balls of ice are quite heavy and then fall to the earth as hail.

5. Dew

Not all forms of precipitation fall to the earth from clouds. There are some types that are formed near the earth's surface. After the sun sets, the earth begins to get cooler. Heat is radiated through the air from objects such as buildings, soil, and plants. The air next to them is cooled below the dew point by conduction and the water vapor condenses on the cool objects as dew, or small droplets of water. It is more likely to form on still nights than on windy nights, because when the wind is blowing the cool air near the earth's surface is mixed with warmer air and the air is not cooled below the dew point. Dew does not often form on cloudy nights because the clouds serve as a blanket to hold in the heat radiated from the surface of the earth.

6. Snow

Snow is formed in clouds where the temperature is below freezing. The water vapor changes directly into crystals of ice as it comes out of the air. The tiny bits of ice unite to form flakes of snow. Like drops of rain, snow flakes fall to the earth when they are too big to float in the air. The large fluffy flakes of snow that fall in some snowstorms are really made of many small flakes that combine while falling.

EVALUATION

1. Why is there always some water vapor in the air?
2. What are the main types of clouds?
3. What causes the formation of clouds, fog, rain, hail, sleet, dew, and snow?
4. Of what value are the forms of moisture in the air?
5. What instruments are used to study different types of air moisture?
6. What are the two main factors which cause water to evaporate?

Things To Do

1. Do experiments to show that heat and wind help water to evaporate.
2. Watch the sky for different types of clouds.
3. Collect snow on a snowy day, study it with a magnifying glass.
4. Make alum crystals in connection with the study of snowflakes.
5. Make some of the instruments used to study the water vapor of the air.
6. Make charts and posters showing the types of clouds.
7. Show that land heats and cools faster than water.

   Cover a thermometer with several handfuls of dirt. Place another thermometer in a pan of water. After both have been left in the sun for some time, read the recordings. Discuss why the recording differ.
8. Let students describe the cloud they like best and tell why.

There is still much disagreement about the formation of cyclones. The major question is where do the cyclones originate--at a high or low level? When many aspects of the higher levels of the atmosphere were unknown, the polar front theory of cyclones was accepted. First, there is a boundary between two air masses. Winds began to move parallel to the boundary since the masses do not readily mix. Edges of the front begins to be uneven as the cold air begins to push into the warm air. A low pressure areas develops at the point where the two masses merge. The denser cold air lifts the warm air, thus forming clouds and precipitation. The winds begin moving in a circle around the low pressure region. A full cyclone has developed. This polar-front theory attributes the formation of the cyclone to the properties of the two masses. There is now evidence that when certain high level disturbances move over a polar front, cyclones are formed. This new evidence shakes the accepted theory and leads scientists into more research and more knowledge.

E. Turbulence

1. Cyclones

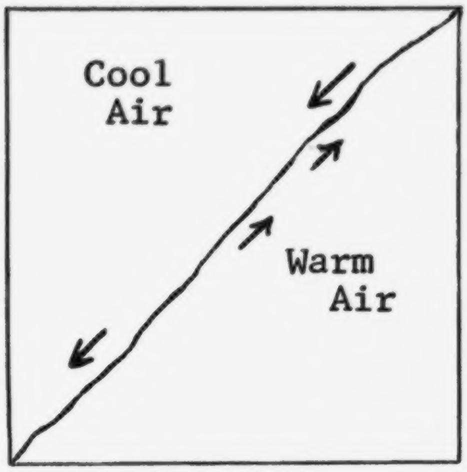
Objectives:

1. How do various weather turbulences differ?
2. How do we explain cyclone formation?

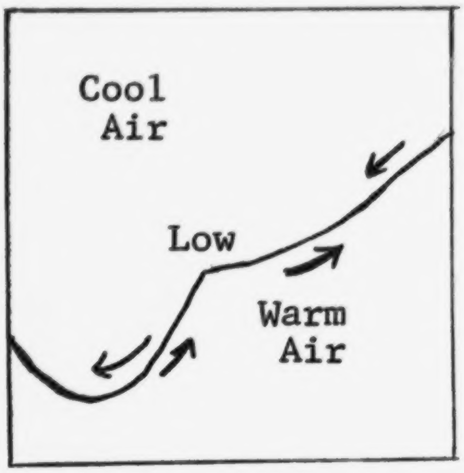
The various turbulences (cyclones, hurricanes, and tornadoes) share much in common. The biggest differences are the strengths of their winds, their sizes, and their duration. The tornado is smallest and lasts for a short time. The hurricane may have a diameter of 500 miles and remain forceful for a week. A cyclone may be 1000 miles or more in diameter and endure for a week. As a hurricane moves over land it evolves into a cyclone.

Most people would become frightened if they were told that a cyclone was forming. They would probably not have a conception of its true nature and would only link it with "hurricane" or "tornado,". Generally "cyclone" refers to a low pressure area with air circulating it and blowing toward its center. (High pressure areas are called anti-cyclones because the winds blow away from the center.) In the winter, long periods of rain and snow characterize their arrival. They are the largest and the tamest of storm centers. They are helpful in bringing rain to crops. Sometimes prolonged cyclones cause floods. This is not a sudden damage like the work of hurricanes and tornadoes.

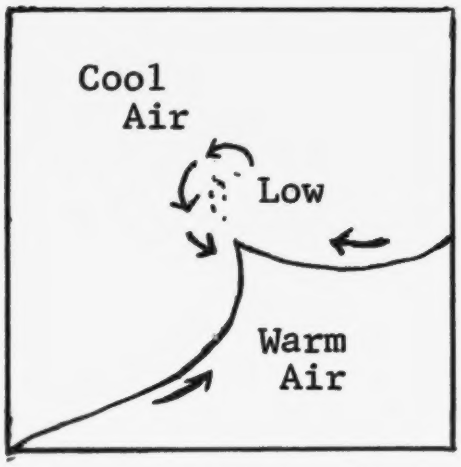
DEVELOPMENT OF A CYCLONE


Cool Air
Warm Air

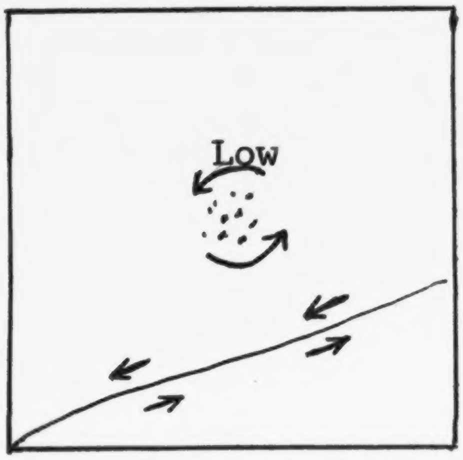
Air masses meet


Cool Air
Low
Warm Air

Cold air pushes into warm air. Low pressure area begins to form.


Cool Air
Low
Warm Air

Winds begin moving in a circle.



A full cyclone has developed.

Activities

1. Follow the formation of a cyclone by use of the daily weather maps.
2. Count the number of cyclones in the United States for a week.

2. Frontal Systems

From our study of cyclones we have learned about air masses and the effects of their movements. Each warm air mass or cold air mass has its beginning in "source regions." There are about twenty source regions in the world. Concentrating on the United States we find that dense polar masses regularly move south from the North Pacific, Canada, and the North Atlantic. In contrast, moist tropical air masses travel north from the Pacific, Gulf of Mexico, and the Caribbean. Our weather is the daily result of these masses meeting and mixing.

The boundary between two different air masses is called a front. Changes in weather take place as a front moves over the land.

Cold Fronts

Imagine a mass of warm moist air settled over an area of land and a mass of cold dry air sweeping in from the north colliding with it. Since cold air is heavier than warm air, the cold air will ride along the ground and nose the warm air out of its position. Along a gentle slope called the "front" the two air masses touch. In this case it is a cold front since the warm air was stationary and the cold front is pushing it out of the way. Cold fronts bring definite weather changes. The cold front gives no warning and is suddenly present. As the warm moist air is cooled there is a formation of mist or fog. Heavy showers are released from large cumulonimbus clouds. The mixture of the air masses causes strong winds. A greater difference of temperature between masses will cause more turbulent weather.

Warm Front

Now imagine a stationary cold air mass is met by a moving mass of warm moist air. As the warm light air meets the cold air it gently rises. At the top of the slope is a formation of feathery cirrus clouds. From dark nimbostratus clouds come a steady rain. At later stages the rain clouds may drop and form fog. The front persists until a cold front moves in to replace the humid air.

EVALUATION

1. Where do air masses originate?
2. What are the differences between a cold front and a warm front?

3. Hurricanes and Typhoons

Typhoon comes from the Chinese word "tia-fung," while hurricane is a term invented by the Carib Indians of the western hemisphere. The difference between the two is that they are located in diverse parts of the world. A hurricane is a destructive tropical storm over the Atlantic Ocean; such storms over the Pacific Ocean are called typhoons.

Hurricanes develop over the warm tropical seas in the low latitudes close to the equator. These storms bear some resemblance to the cyclones of the middle latitudes. However, hurricanes are seldom more than a few hundred miles in diameter. Some of the characteristics of a hurricane are that the storm probably begins as a disturbance in the trade winds which blow over the sea near the equator. High altitude winds carry very moist warm air into the upper levels of the atmosphre. The moisture in the rising warm air condenses, releasing great quantities of heat, which by further warming of the air cause it to rise even faster. This rising of air causes more moist tropical air at lower levels to be drawn into the column. The effect of this rising air introduces a continuous supply of water vapor to keep the process going. The rotating motion of the air as it rushes toward the center of the storm is believed to be the result of Coriolis force acting upon winds.

A hurricane consists of a series of thick black clouds with heavy precipitation, which spiral into the storm's center. The eye of the hurricane is the exact center and is a relatively calm, quiet region about 12 to 15 miles in diameter. The winds increase in velocity toward the eye, with maximum speeds usually over 100 miles per hour. Much of the damage of a hurricane is caused not only by the high winds but also by the flooding which accompanies the extremely heavy rains. Hurricanes weaken when they move inland. The reason for this is that a hurricane must have a constant source of warm water vapor for formation and existence.

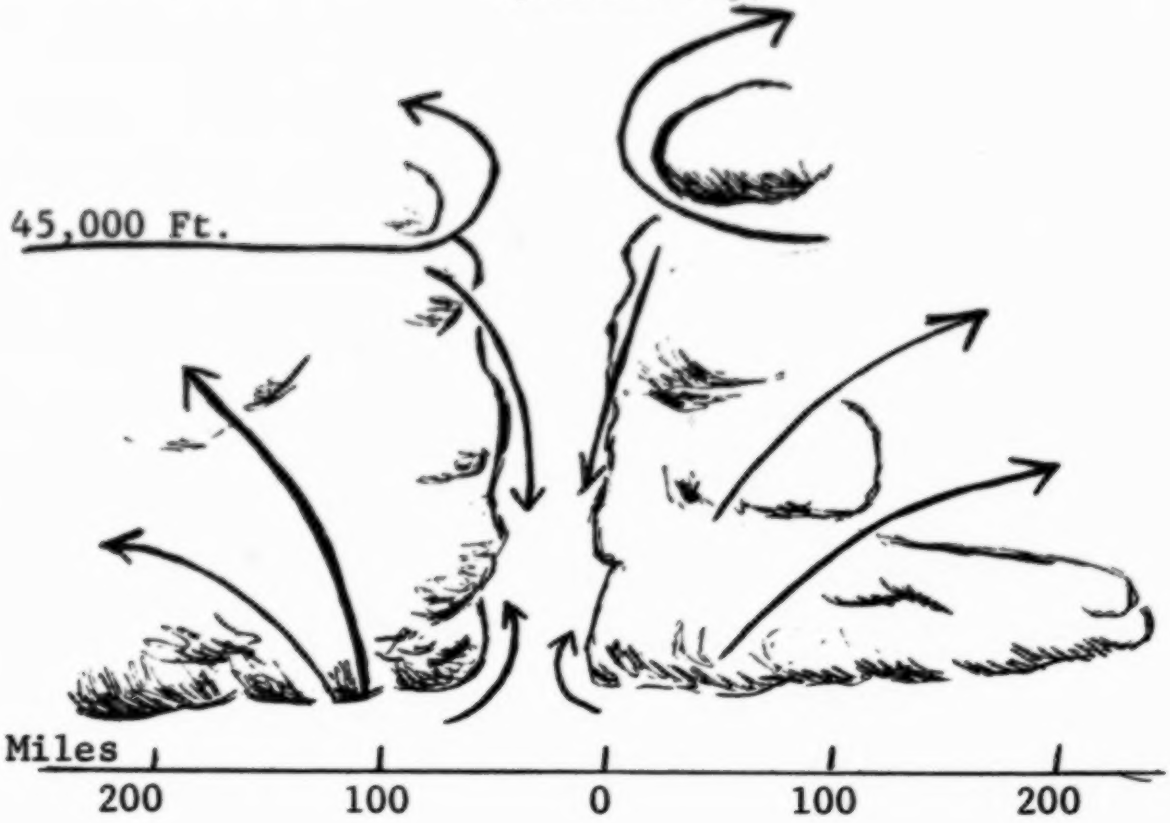
Hurricanes that form in the Atlantic Ocean are usually stronger and larger than those of secondary areas in the Caribbean Sea and the Gulf of Mexico. These storms are equally destructive and often more dangerous because their paths are less easy to predict. Hurricanes of Caribbean or Gulf origin do not usually extend as high or as deep. The shallower and smaller storms of this area are able to change direction easily.

Signs of hurricanes are: the air pressure falls more rapidly than it does in a frontal storm, the speed of the winds become more rapid and gusty. The temperature is usually above normal. There is a large amount of water vapor present.

A typhoon is formed in the same manner as a hurricane. The only difference is that they occur in different parts of the world. The typhoon is found in the Pacific Ocean.

More tropical storms occur around the Philippine Islands, Japan, Okinawa, and the coastal area of China than any other part of the world.

AIR MOVEMENT WITHIN A HURRICANE
(vertically)



EVALUATION

1. What is the difference between a hurricane and a typhoon?
2. How are hurricanes formed?
3. What are some signs of approaching hurricanes?
4. What is the "eye" of a hurricane?
5. Why are the hurricane paths of our Gulf region hard to predict?
6. What area of the world has the most tropical storms?

Activities

1. Make reports on damage caused by hurricanes and typhoons.
2. Follow these storms in the news media.
3. Where and when do these storms occur?

4. Tornadoes

The tornado is the smallest, most violent and short-lived of all storms. A tornado is most likely to occur on a hot, humid day when the sky is filled with heavy thunder-clouds. Suddenly, one of the cloud bases develops a funnel-shaped twisting extension that reaches down toward the earth and moves in a wandering path at a speed of 25 to 40 miles per hour. A tornado generally does not sweep a path any more than 500 yards in width, but within that path destruction is very great. Winds whirling within the funnel are estimated to reach a velocity of 500 miles per hour.

The pressure within the funnel is extremely low. Because of this low pressure a building may literally explode from the sudden pressure drop as the tornado passes. Fortunately, the average life span of a tornado is only about eight minutes.

The tremendous power that a tornado is able to develop has been a complete mystery, but much empirical evidence supports the fact that it is electrical in origin. Current Science on April 5, 1967 carried an interesting description of this. Tornadoes are the result of great differences in the properties of two air masses. For a tornado to form, it appears to require moist warm air at low levels and cool dry air at upper levels. There is also some sudden lifting action such as that caused by an advancing cold front.

Best conditions for a tornado are formed ahead of a severe cold front, when the air ahead of the front is very moist. The release of large amounts of energy, the rushing of strong currents of air which results, and the whirling effect of the earth's rotation all contribute to forming a tornado.

Tornadoes are most frequent during spring and early summer, and they are most likely to occur during the afternoon. The average number of tornadoes reported in the United States is about 200 a year.

EVALUATION

1. What is a tornado?
2. What conditions are necessary for a tornado to form?
3. What is the average number of tornadoes in the United States per year?
4. What period of the year do most tornadoes occur?
5. What is the shape of a tornado?

Activities

1. Tornado chamber--refer to Basic Earth Science. Singer Science Series.
2. Make reports on tornadoes' damage.
3. Follow tornadoes in the news media.
4. Make charts showing number of tornadoes that occur in certain months of the year.

CHAPTER VI

What are some of the instruments and techniques which will enable man to explore the universe?

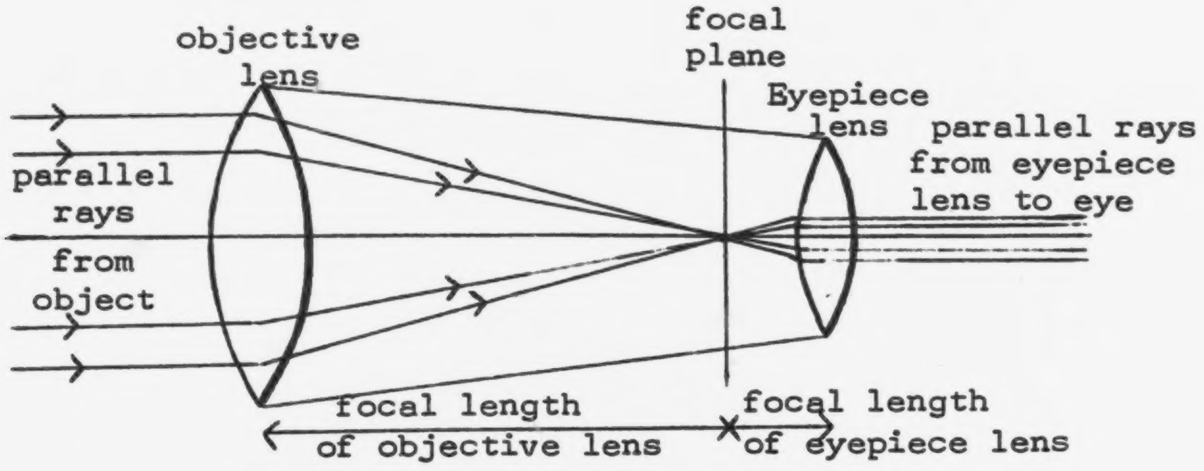
UNIT III. HOW CAN I GAIN A BETTER UNDERSTANDING OF THE SOLAR SYSTEM AND THE UNIVERSE?

Objectives

1. How do optical and radio telescopes help me investigate the universe?
2. How is it possible for me to determine the chemical composition of things not even on the Earth?
3. How can I determine whether a thing is moving toward me or away from me in the vast expanse of space?

6.1 Telescopes

A. Refracting telescope - This telescope is so named because it uses a large glass lens to refract or bend the light waves to bring them into focus and form an image. Use a magnifying lens to form an image of the Sun on a piece of paper. Is this the image produced by a converging lens? If it is, the focal length of the lens will be the distance from the lens to the image, because the object (the Sun) is a great distance from the lens. The refracting telescope is a combination of two lenses. The objective is a converging lens of a large diameter and long focal length so that it will gather large quantities of light. The eyepiece magnifies the real image produced by the objective lens. (The magnifying power is approximately equal to the focal length of the objective, fo, divided by the focal length of the eyepiece, fe, or m = fo/fe).


objective lens
focal plane
Eyepiece lens
parallel rays from eyepiece lens to eye
parallel rays from object
focal length of objective lens
focal length of eyepiece lens

The Optical System of a Refracting Telescope

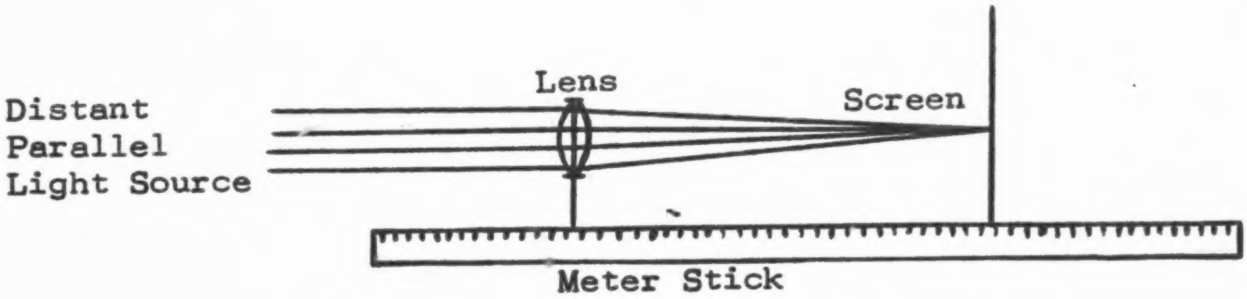
Experiment: Preparation of a refracting telescope by a converging lens combination.

Equipment Needed:

1. 2 lens clamps
2. meter stick
3. Sheet of paper to act as screen
4. Two converging lenses (one must have a shorter focal length than the other if magnification is to result from their combination).

Procedure:

1. Finding the focal length of each lens:



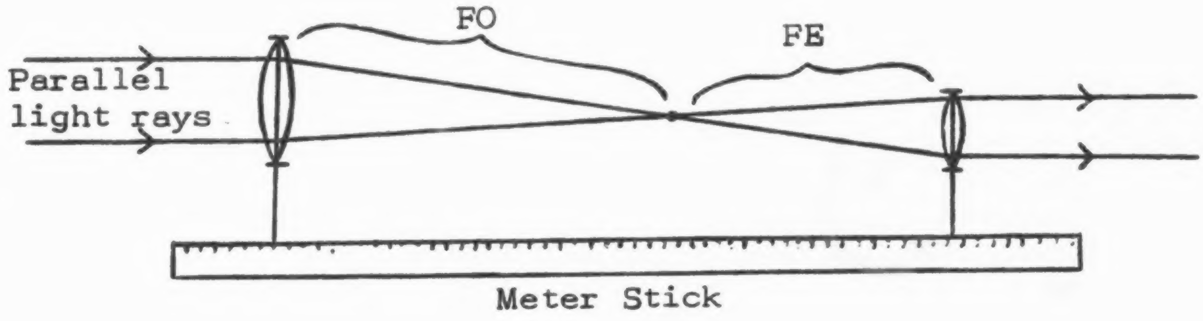
Set up equipment as seen in diagram. Point lens toward a distant light source in order to get parallel rays. Move lens up and down meter stick until an image forms on the screen. Find the distance between the lens and the screen. This distance will be the focal length. Repeat this procedure for the other lens.

2. Arranging the telescope

Place both lenses and clamps on the meter stick. Their distance apart should equal the sum of their focal lengths. Point the larger one toward the object to be magnified.

Look through the smaller one. The image should appear distinct. If the image is not sharp, slowly move the smaller lens until it becomes distinct.

3. Explanation of parts of prepared telescope: The smaller lens will act as the eyepiece while the larger lens will be the objective lens. Let the focal point of the eyepiece be (fe) and the focal length of the objective be (fo). The magnification = fo/fe as stated earlier.

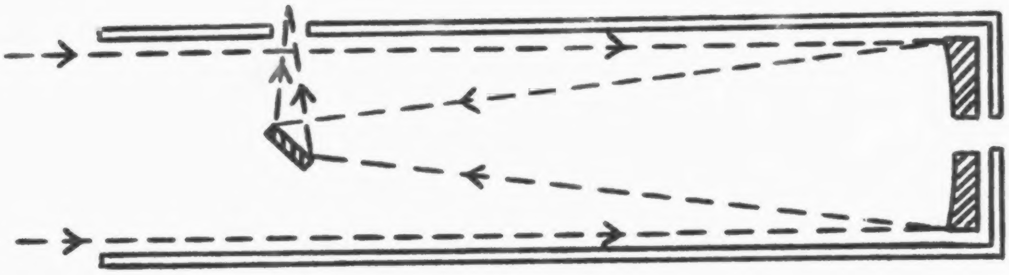


B. Reflecting telescope

If a beam of light from a distant source is allowed to fall on a concave reflecting surface such as a mirror, the rays of light are brought to a focus on the same side of the mirror as the object. Hence a concave mirror will form an image of a distant object by reflection, and thus can serve as the objective of a telescope.

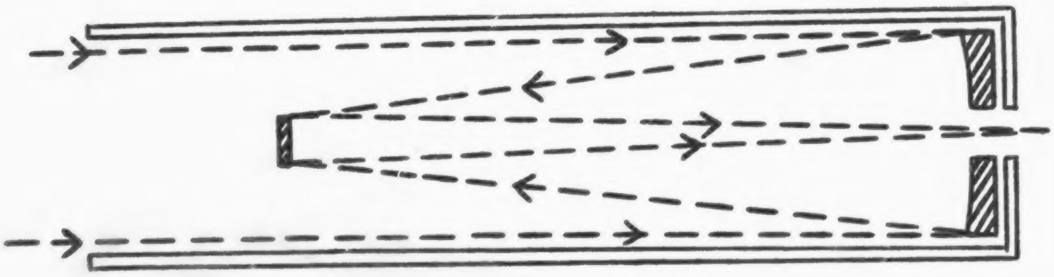
In the very large telescopes a cage is constructed at the prime focus, and hence the image is accessible to the observer. Frequently a photographic plate is used in the place of an eyepiece to record the information received.

This method can only be used in the larger telescopes where the size of the cage would not obstruct a major portion of the light coming into the mirror. In the smaller telescopes there are primarily two methods used to make the final image accessible to the observer. In the Newtonian form, a small plane mirror is placed in front of the focal point at an angle of 45° to the axis of the telescope. This plane mirror reflects the converging beam from the objective mirror to a focus at the side of the tube.



Newtonian Reflecting Telescope

The second method used simply replaces the small plane mirror with a small convex mirror placed perpendicular to the axis of the telescope. The convex mirror reflects the beam back through an opening in the large mirror to the eyepiece below. This form of reflector is called the Cassegrainian form.



Cassegrainian Reflecting Telescope

The chief optical feature of any telescope is its objective, either a lens or mirror, which must receive the light from a celestial object and focus the light to produce an image. The size of a telescope is denoted by the re-clear diameter of the objective. For example a 16 inch reflecting telescope will have as its objective a concave mirror with a clear diameter of 16 inches. The largest refracting telescope is located at Yerkes Observatory at Williams Bay, Wisconsin. Its lens is 40 inches in diameter and its focal length of 63 feet. The largest reflecting telescope is the 200 inch telescope at Palomar Observatory in California.

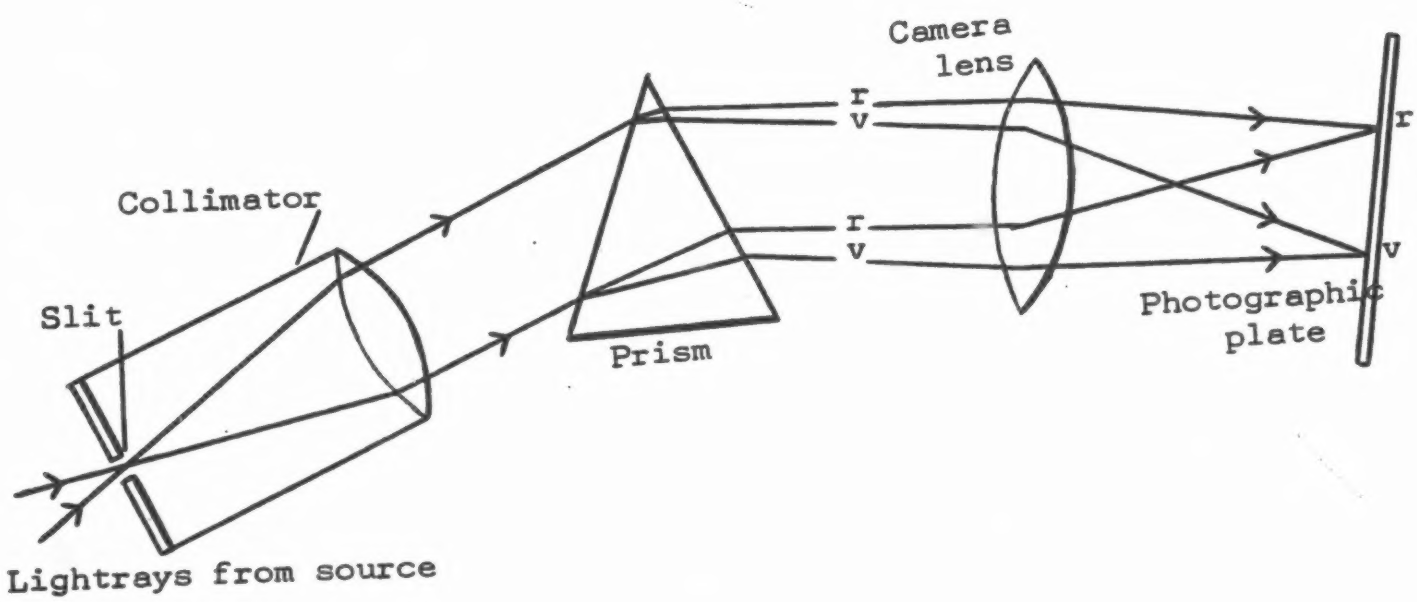
C. Radio Telescope

Radio waves from outer space are invisible but they can be detected. Instead of using glass lenses or mirrors to collect light waves, radio waves are collected by enormous saucer-shaped or radar-type antennaes and fed into special radio receivers. These record the strength and wavelength of the signals as well as the direction from which they come. It is now known that one of the sources of radio waves are thermal radiations produced by the ions in clouds of hot gases or nonthermal radiations of high speed atomic particles like those in a cyclotron.

Radio waves vary from about one-fourth of an inch to many feet in length. Since the radio waves are so long, the dish of the radio telescope must be huge. Looking at the dish close-up, you will see an antenna at the center. When radio waves strike the dish, the waves are reflected or transmitted to the antenna at the center. In the antenna the radio waves are changed to an electric current and sent to the receiver.

6.2 Spectroscope

For a better understanding of the stars it is necessary to consider a new instrument, the spectroscope. This instrument is second only to the telescope as an instrument used by astronomers in research. The spectroscope consists primarily of three parts; the collimator, the prism, and the viewing telescope. See diagram of a spectroscope below.


Camera lens
r
v
r
v
r
v
Collimator
Slit
Prism
Photographic plate
Lightrays from source

The Three Parts of a Spectroscope

The collimator has a narrow slit at one end and a converging lens at the other end. The slit is located at the focal point of the lens, thus as light enters the slit and passes through the lens it becomes a parallel beam of light and is sent into the prism. The purpose of the prism is to refract and disperse the light so that it can be analyzed. When light passes through a prism, the longer wave lengths are refracted less than the short wave lengths. In other words the wave lengths, corresponding to red in the visible spectrum, are not bent as much as the wave lengths corresponding to violet. Thus the beam of light is dispersed by refraction into a spectrum. This spectrum is brought into focus by the viewing telescope.

A. Types of Spectra

Fundamentally there are three kinds of spectra: the continuous spectrum, the bright line or emission line spectrum, and the dark line or absorption spectrum. The continuous spectrum, in the visible region, is a continuous arrray of colors ranging from red through violet. The source is a luminous solid or liquid emitting all wave lengths.

The bright-line spectrum is an array of bright lines against a dark background. The source is a gas that emits a characteristic selection of wave lengths. Each gaseous element emits a particular pattern of lines, and thus the source can be identified by its spectrum.

The absorption spectrum is a pattern of dark lines on a bright background. This spectrum is caused by a gas between the observer and a source that would emit a continuous spectrum. The gas absorbs certain wave lengths from the light coming from the source that it would emit under similar conditions. Thus by its absorption pattern the gas reveals its own chemical composition.

Experience: Making a spectrum.

Purpose: To demonstrate the formation of bands of color from white.

"White" sunlight is made up of many different wave lengths. Each wave will travel through glass at a different speed, therefore the waves are spread out. If they are caught after they leave the prism, they will form bands of distinct colors.

Equipment:

1. Tray of water
2. Pocket mirror
3. Source of sunlight

Procedure: Set the tray near the window in a steady stream of light. Lean a pocket mirror in the water where the sun will reflect off of it after it passes through the water. Adjust the mirror until the spectrum appears on the wall. Allow the students to try to distinguish between the colors.

B. The Doppler Effect

The relative motion of the stars can be determined by using the spectroscope and observing the Doppler Effect.

Imagine that you are standing by a railroad track and a train is coming. Can you remember the way that it sounds from an experience in the past? The pitch of the horn rises as the train nears you and, afterward, falls as it passes. The sound waves are pressed closer together as it nears you and pulled farther away as it departs.

Light waves operate in this same manner. Therefore, an astronomer is able to get a fix on a star and make a series of observations to determine whether a star is moving away or toward the earth.

This Doppler Effect can precisely be stated in the form:

$$\frac{\text{Change of wave length of a line}}{\text{Normal wave length of that line}} = \frac{\text{Velocity of approach or recession}}{\text{Velocity of light}}$$

We can state the above in the following manner: If the source of light and the observer are approaching, the lines of the spectrum are displaced toward the violet end of the spectrum; while if the source and the observer are receding from each other, the lines in the spectrum are displaced toward the red, the displacement of the lines being proportioned to the velocity of approach or recession. These displacements are respectively referred to as the violet or red shift.

CHAPTER VII

HOW DO WE ATTEMPT TO EXPLAIN THE ORIGIN OF THE PLANETS?

Objectives:

1. How was our orderly solar system originated?
2. Why should I consider "theories" of formation of the planets?

Introduction

Our solar system as we know it today is basically an orderly arrangement of nine planets and a multitude of smaller bodies orbiting the Sun with predictable precision. All planets and planetoids are subjected to the Sun's powerful gravitational pull. How was this collection of satellites, our Earth among them, originally acquired by the Sun? For thousands of years, mankind has pondered on this question and offered answers. Still, modern science lacks a definite answer suitable to his cultural background, but continues to hypothesize on the origin of the closely packed celestial system. Odds are overwhelmingly against a purely chance formation of so many similarities in the solar system that evolutionary process presently seems more defensible. Logic seems to justify an assumption that the explanation of the Sun's family may be related to the development of the Sun itself.

7.1 Planetesimal Theory

A heavenly body as large or larger than our Sun passed near enough to the Sun in space to cause an enormous gravitational attraction. This intense force caused part of the Sun's matter to be pulled away from the Sun into space. As the great masses of material moved toward the large passing star, they were given an angular velocity to provide the initial energy for putting this matter into orbit about

8 neg.

the Sun. How could this occur? As the hot material cooled, small bodies (planetoids) were formed, which eventually collected together and became planets. This theory of formation has been modified substantially in several newer versions. The different versions of the planetesimal theory all share a common inadequacy. Most evidence indicates that matter taken from the Sun or any other star would be so hot that it would quickly spread out into space as a gas before cooling sufficiently to become solid.

7.2 Kuiper's Theory

Among the newer theories is the Kuiper hypothesis, which suggests that while the Sun was in the process of condensing from the mass of interstellar matter, outer envelopes of gases and dust were also condensing. The enlargements in the gaseous envelopes were called protoplanets or primitive planets. As the Sun condensed, it became hotter and hotter until it began radiating immense amounts of energy. This radiant energy was sufficiently intense to drive the lighter gases away from the outer envelopes of the inner protoplanets. Subsequently, soon the planets nearest the Sun were devoid of an atmosphere. This is when Earth lost most of its lighter gases. Many of the gases presently in the atmospheres of Earth were formed later. Heavier matter became the cores of the planets while lighter matter became asteroids, meteors, and satellites of the planets. Does this raise any questions in your mind? As the mass of gas and dust condensed, radioactivity was produced in the earth. The energy released by radioactive elements caused the core of the planet to become hot. The gravitational attraction of the Earth caused nearby particles to increase its mass; but still there was one lump of matter which passed an orbital inertia that balanced the Earth's gravitational pull and became the earth's only natural satellite.

As the heavier elements were drawn toward the center of the earth, the lighter elements floated nearer the surface. It is possible that when condensation had reached the point of forming solid and liquid, in addition to the gaseous state, the Earth's lithosphere was smooth and water formed a continuous film on the surface.

7.3 Dust Cloud Theory

About the time of President Washington's second inauguration, Laplace, a French astronomer, proposed the idea that the solar system may have begun as a vast saucer-shaped hot cloud of gas and dust slowly rotating in space. For some unknown reason, as the cloud cooled and shrank, it began to spin faster, causing rings of matter to break loose from the outer edge. From the series of rings formed around the central mass of material planets were evolved and the central mass became our Sun. This dust cloud theory of Laplace was popular among scientists for many years, but later mathematical analysis showed some serious flaws. How could rings of light materials be changed and collected into globes of matter as large as planets? Even though Laplace's theory was not completely sound, it provided a basis for the explanation of the origin of the solar system widely accepted by astronomers today. If you are curious about this theory, you may wish to read some of Fred Whipple's writings first appearing during Harry T. Truman's administration.

7.4 Other Theories

A theory in close agreement with contemporary factual evidence was originally proposed by Carl Weizsäcker. It has been revised by others, and is based in part on the explanation of the processes by which stars are formed while the residual remained around the new star as a great rotating disk. Later, huge whirlpools which developed within the disk, caused the formation of smaller globes of gas and dust. These extra-solar globes of material cooled to form planets, which presently revolve around the Sun as a result of the original motion of the spinning disk of gas.

One convenient aspect of this theory is that it does not require anything unusual happening to explain motion and existence of satellites. If such a theory is correct, many other stars in the universe may also have systems of planets. It is even possible there could be other planets very similar to the Earth. Enormous distances to even the closest stars make it virtually impossible to establish empirically the existence of other solar systems.

Man's investigations in the vastness of space are scarcely embryonic today, and new laws as well as instruments of scarcely imaginable precision must be discovered before any theory of formation of the solar system can hope to receive substantial report. Until that time it is well that man continue to speculate and offer theories in order that he might investigate them at a later time when his knowledge is more complete. Try developing and supporting a theory of your own.

Conclusion

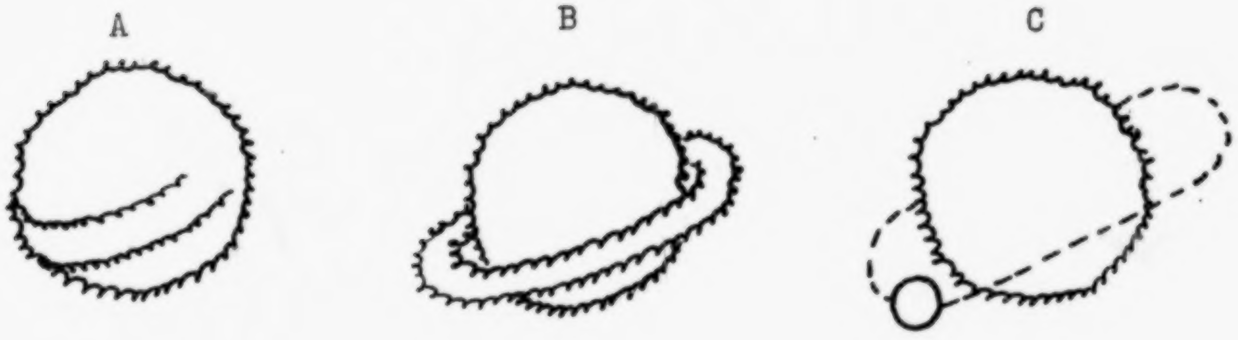
Some scientists feel Kuiper's hypothesis is a reasonable one, while other geologists are still investigating the problems of the Earth's development and its relation to the Sun. Can you find shortcomings in Dr. Harold C. Urey's summarization of the course of events as reported by Helen McCracken?

1. A vast cloud of dust in an empty region of our galaxy was compressed by starlight. Later, gravitational forces accelerated the accumulation process.
2. In some way not yet clear the Sun was formed.
3. Around the Sun wheeled a cloud of dust and gas which broke up into eddies or whirls that formed protoplanets.
4. At this stage the accumulation of large planetesimals took place.

5. At first, the temperature of these was low, but later the temperature state, water accumulated in these objects. At the high temperature stage, carbon was captured.
6. Now the gases escaped, and the planetesimals combined by collision. So, perhaps, the earth was formed.[1]

What changes and uncertainties are found here that were not part of earlier hypotheses?

THE NEBULAR HYPOTHESIS



"How the planets were formed, according to Laplace's nebular hypothesis. A vast rotating mass of incandescent gas gradually cooled and shrank, and became more and more spherical in shape. As it rotated faster it developed a bulge around the equator. (A) Finally a ring of matter was flung off from the central mass. (B) It cooled, contracted and became a solid planet with its orbit in the plane that the ring formerly occupied. (C) Other planets were formed in the same way, according to the theory; the central mass became the Sun."[2]

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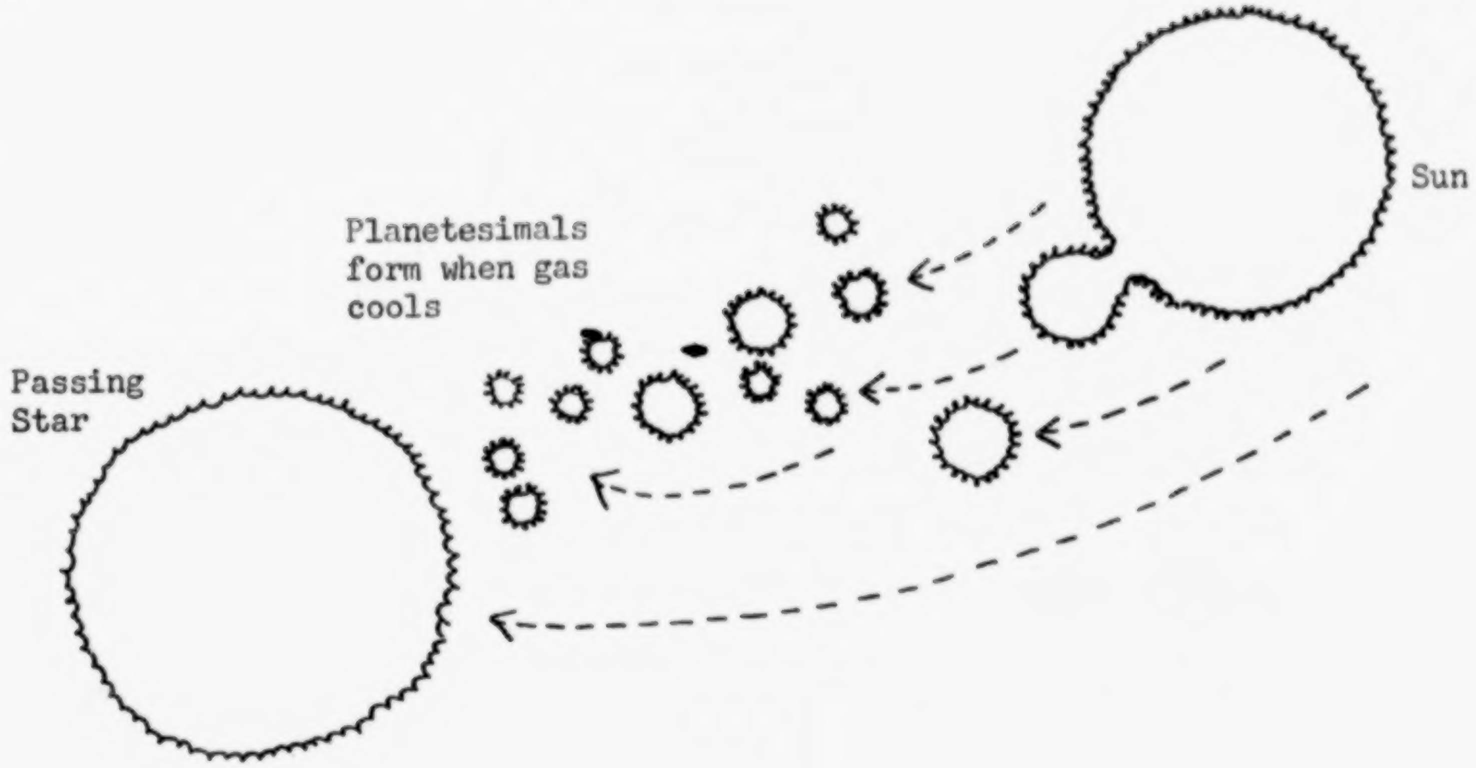
[1] McCracken, Helen Dolman, et al. Basic Earth Science, Chicago, Illinois: The L. W. Singer Company, 1964. pp. 20-21.

[2] The Book of Popular Science, Vol. I. New York: The Grolier Inc., 1963. p. 28.

PLANETESIMAL THEORY


Sun
Planetesimals form when gas cools
Passing Star

"According to the Moulton-Chamberlin planetesimal theory, a star approached the Sun and pulled from it a mass of gas. These cooled into liquid and at last they became small, solid masses--planetesimals. Eventually the planetesimals. Eventually the planetesimals drew together and formed planets."[3]

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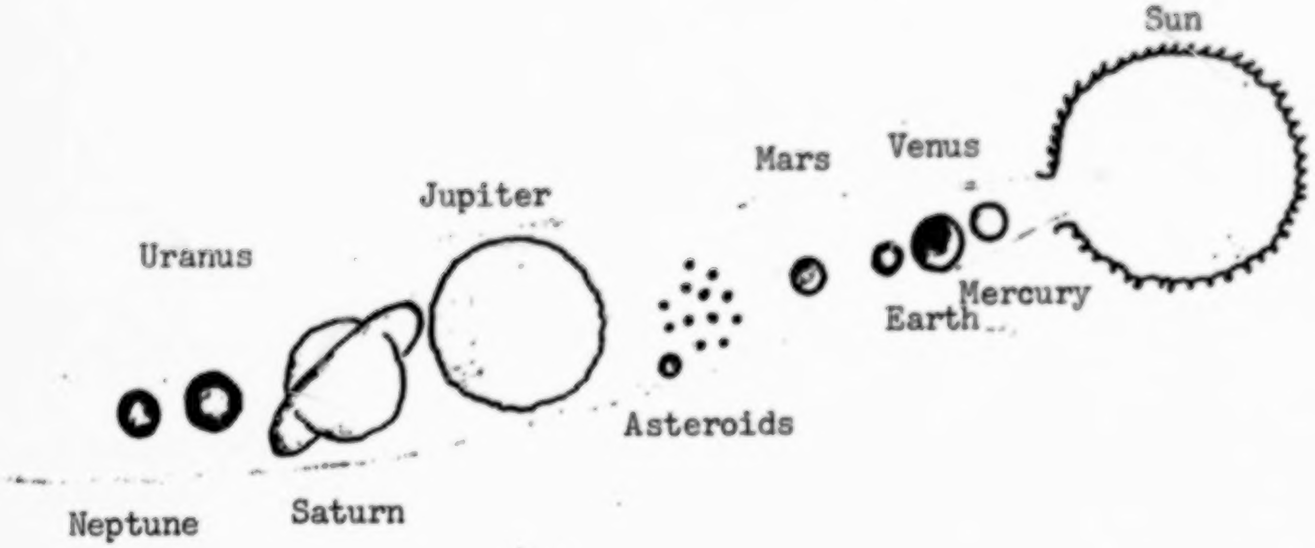
[3] Ibid.

THE TIDAL THEORY



"The tidal theory of Jeans and Jeffereys. They held that the planets were formed from a cigar-shaped filament of gas which was pulled from the Sun by a passing star. The smaller planets were derived from the ends of the filament; the larger ones, from the central section. The planet Pluto is not included because it was not known at the time the tidal theory was proposed (in 1918).[4]

What are some theories as to the origin of the solar system?

Activities

1. Do library research and do reports on other theories (nebular, tidal, etc.)
2. Prepare reports on scientists: Hoyle, von Weizacker, Laplace, Moulton, Chamberlin, Jeans, Jeffereys, Kuiper, Kant, Buffon, Lyttleton, Whipple.
3. Make posters to illustrate various theories.
4. List questions about the formation of the solar system and earth that the students would like answered.

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[4] *Ibid*.

5. Creativity
    a. Make a diagram to show how you think the solar system might have appeared to an observer in space just after the star had passed the Sun.
    b. Draw a second diagram to show how you think the solar system might have appeared millions of years later when the planets were partially formed.
6. Appoint three interested students to make a model or a drawing to scale of the solar system.
7. Have students search for information about the Sun and make a comparison of it to other suns.
8. Demonstrate a method of making a refracting telescope and encourage students to build telescopes with small lenses.
9. Assign a committee to determine the relationship between Sun and life.
10. Assign a group to plan a visit to the planetarium to help with answers to some of the questions.
11. Select an interested student and ask him to make a theoretical structure of the solar system Sun, or universe, and place this on the bulletin board.
12. Have several students to trace each form of energy to the Sun.
13. Hold class discussions on all the theories about the origin of the solar system.
14. Discuss with the class possible future developments which might alter present knowledge of the solar system.

15. Have each student write a short story (along science fiction lines) on "What Happens When the Sun Goes Out?" or "The Last Day on Earth Without the Sun," or some other similar title.

EVALUATION

1. Was student interest stimulated?
2. Did the students understand the theories presented?
3. Were the fallacies of the theories presented clearly?
4. Was further research upon the part of the student encouraged and did they follow through?
5. Were students challenged to give their own theories of origin?

SUGGESTED EVALUATIVE PROCEDURES

1. Give written teacher-made test over the problem.
2. Evaluate student reports (oral or written).
3. Examine orally for general concepts and understanding.
4. Check drawings, charts, posters, stories, or telescopes.

QUESTIONS (ORAL OR WRITTEN) FOR TEACHER-TEST EVALUATION

1. Name four hypothesis which attempt to explain the formation of the solar system.

    How did it all begin?

    How did it develop?

    Where will it all end?

2. Give a very short and simple version of the planetesimal theory.

3. Give satisfactory explanation and shortcomings of the different theories with possible explanations.

4. What explanations of the origin of the earth have you heard? Did they seem reasonable or not? Why?

5. Does the solar system seem to have order?

6. Do you think man's gradually increased knowledge of the solar system has made any difference in his ways of living and thinking?

7. Do we understand what has happened in the past and what may happen in the future?

8. Can we assume the forces and processes at work today also were in operation in the past, and will continue in the future?

9. What is the solar system composed of? (a) Bodies. (b) Elements.

10. How does the force of gravity affect the universe? Our solar system?

CHAPTER VIII

What are the similarities and differences between the planets located closest to the Earth?

Objectives

1. How can I increase my knowledge of the vastness of space and the universe?
2. What are some of the identifying characteristics of the inner planets which would make travel to them interesting?
3. How can I explain the formation of the asteriod zone?

Anyone who watches the constellations in the heavens from night to night has occasionally discovered a visitor in this or that group. It will be noticed that these visitors shine with a clear, steady light in contrast to the "twinkle" of the surrounding stars. They appear to move across the constellations, sometimes from the east to the west, sometimes from west to east. Their name, "planet," comes from an old Greek word, planete, meaning "wanderer," but the Greeks recognized regularity in the wanderings of the planets.

To the unaided eye, planets look very much like stars, but several visible differences help us tell them apart. First, planets change their position in relation to each other and in relation to the stars in their travel around the sun. True stars apparently keep the same formations. A second difference is that the telescope can only make stars look brighter, but not larger, because they are so very far away. But planets are near enough to the earth to be magnified by the telescope into bright circles or discs rather than just bright spots of light. A third difference between stars and planets is that stars always seem to twinkle, because of changing refraction that is a result of vertical movements of warm and cold air and the horizontal movements of air layers of different densities. These bend and disturb the ray of light from a faraway star. Planets, on the other hand, shine with a steady light, because their large circles send out enough rays of light so that not all of them are cut off at one time.

Some of the planets look much brighter than the stars because they are much nearer and because their surfaces are good light reflectors. Of course stars shine with a light of their own, while planets reflect light from the sun.

In order of their increasing distance from the sun, the known planets in the sun's family are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. Between Mars and Jupiter are the asteroids or the "minor planets."

The "inferior planets" or inner planets are the first four in their order from the sun, and include Mercury, Venus, Earth, and Mars. The other five are the "outer planets."

The solar system includes many things...the sun, Earth, other planets, satellites, comets, and anything else that keeps moving under the effect of the sun's gravitational pull or force. There may be, however, much more to the solar system than man has seen at this time. For example, Pluto had not been seen before 1930. But, as far as we know now, there is no natural law limiting the number of planets in our solar system. In order for a planet to revolve around the sun, it must lie within the sun's effective gravitational field. That much is obvious, but just where the sun's gravitational field loses its power to control planets is not quite so obvious.

There is a mathematical progression that was discovered by Titius of Wittenberg in 1776. It is now frequently referred to as Bode's Law, but it is not a physical law in the true sense; it is simply a scheme for remembering the distances of the planets from the sun. The progression can be obtained by writing down the 0, 3, 6 (doubling each previous number to get the next number). Now add 4 to each of the numbers and divide the sum by ten. The results give the approximate distances from the sun to the planets known in 1766. The distance is in astronomical units where by definition, one astronomical unit is the average distance from the sun to the earth (929 million miles). Uranus was not discovered until 1781, but it was found to fit fairly well into Bode's Law.

Planet	Progression	Actual Distance in Astronomical Units
Mercury	(0 + 4) ÷ 10 = 0.4	0.387
Venus	(3 + 4) ÷ 10 = 0.7	0.723
Earth	(6 + 4) ÷ 10 = 1.0	1.00
Mars	(12 + 4) ÷ 10 = 1.6	1.52
Asteroids	(24 + 4) ÷ 10 = 2.8	
Jupiter	(48 + 4) ÷ 10 = 5.2	5.20
Saturn	(96 + 4) ÷ 10 =10.0	9.54
Uranus	(192 + 4) ÷ 10 =19.6	19.2

Bode's Law

8.1 Mercury

Mercury, named for the swift messenger of the gods, is the fastest, hottest, and smallest of all the planets. It is hard to see because it stays so close to the Sun, but it is believed that its periods of revolution and rotation are equal (88 days). Therefore, one of its sides always faces the Sun.

Because it is so near the Sun, the planet receives approximately seven times as much heat and light per unit area as does the Earth. The side of Mercury that continually faces the sun has a temperature of about 640° F., which is hot enough to melt lead. The temperature of the night hemisphere of the planet is probably less than -400° F.

Mercury has no satellites and because of this, its mass is difficult to determine, but a good approximation would be about one-eighteenth that of the Earth. The diameter of Mercury is 2900 miles, which makes it the smallest of the planets with the exception of Pluto.

Usually the planet is too close to the sun to be visible to the unaided eye, but occasionally it is visible in the west after sunset and in the east before sunrise. For this reason it is often called the "evening star" and the "morning star." Both Mercury and Venus show phases like the moon as viewed with a telescope.

8.2 Venus

Venus, named for the goddess of love and beauty, is the second planet in order from the Sun. It is the planet nearest the Earth, and its mass, size, and density are comparable with that of the Earth. It appears at twilight in the western sky (and then is known as the "evening star"), or just before dawn in the eastern sky (then it is the "morning star"). Even though it is relatively close to Earth, Venus' surface is completely hidden from us by a thick veil of clouds. The composition of these clouds is not definitely known, but some astronomers believe it may be hydrocarbon compounds, similar to our smog. Water and oxygen, so necessary to living things on Earth, are very rare on Venus. That fact seems to prove that there is no life such as we know it upon Venus. Dark and bright bands in the clouds are thought to be clouds of yellow dust, and much carbon dioxide is in its atmosphere. Venus revolves around the Sun once every 225 days in a nearly circular orbit, and it is estimated that its time of rotation is 30 days, although much evidence points to a period of rotation equal to its period of revolution. Venus is the third brightest object in the sky, with the Sun being brightest and the moon the next brightest.

Venus, like Mercury, has no satellites and therefore its mass must be calculated from the perturbations it produces upon the motion of the Earth. In this manner it is found to be 0.82 as massive as the Earth. It has a diameter of 7700 miles, which is only slightly less than the diameter of the Earth.

The average distance from Venus to the Sun is about 67 million miles as compared to 93 million miles for the Earth. Venus thus receives about twice as much solar energy per unit area as the Earth, and should have a warmer climate than ours, but we do not know how much of it penetrates the dense atmosphere and actually reaches the surface of the planet.

8.3 Earth

Earth, the third planet in distance from the Sun, probably gets its name from Gaea--earth--the Greek goddess of soil fertility who was the mother of Uranus and the Titans. It is the only planet on which intelligent life is known to exist. It revolves about the Sun at an average distance of 92,900,900 miles. The Earth's axis is tilted at an angle of 23 1/2° away from the perpendicular which gives rise, along with its movement about the Sun, to the changing of seasons, and the changing length of the sunlit day. Its period of rotation is about twenty-four hours, and its period of revolution is 365 1/4 days. Its third motion is that it wobbles slightly as it revolves and rotates. The orbit of the Earth is an ellipse. The Earth has one natural satellite with a diameter of 2,160 miles, compared to Earth's 7,900 miles--slightly more than one-fourth the diameter of Earth.

8.4 Mars

Mars, named for the god of war who caused bloodshed, is sometimes called "The Red Planet." Perhaps its red color, which is generally thought to be a surface of red iron oxide, now contains most of the oxygen which was once in the Martian atmosphere. Mars has two tiny satellites which race in their orbits around the planet. These little satellites, Deimos (fear) and Phobos (terror) are exceedingly small...Deimos is estimated to be five miles in diameter and Phobos only ten. Deimos encircles the red planet five times every four days, while Phobos travels so swiftly in its orbit that it circles the planet three times each day. They are the smallest moons known in the solar system. Mars has polar caps which are thought to be thin covers of ice and snow that increase and decrease in size. Its atmosphere contains very little water, according to the spectral analysis. Mars' average temperature is thought to be around - 40° C. It has blue-green markings which some believe to be lichen, a lowly form of plant life found here on Earth. Mars presents an aura of mystery concerning the fine dark lines on its surface which have never been photographed clearly. A few astronomers say they have had brief glimpses of these lines when visibility was near perfect; other astronomers say that no lines exist. In

1965, Mariner IV passed within 15,000 kilometers of Mars and the photographs transmitted to Earth from that exploration showed no lines, no canals, and no signs of life; it did, however, show craters much like those on the moon.

The average distance of Mars from the Sun is 141,690,000 miles, and its period of revolution is 687 days. Since this is about twice the Earth's period of revolution we would expect the Martian seasons to be twice as long as those of the Earth. This is clearly indicated by the changing size of the "polar caps" as first one axis then the other is tilted slightly toward the Sun.

Mars is only about 0.107 as massive as the Earth, and its diameter is about 4200 miles. Mars has a surface gravity of about 38 per cent of the Earth. Thus a man weighing 150 pounds on Earth would "weigh" only about 57 pounds on Mars.

8.5 What is meant by "Miniature Planets?" Asteroids.

The "miniature planets" or "minor planets" or asteroids are a vast host of very small planets that revolve around the Sun in orbits that nearly all lie between Mars and Jupiter, though a few of them go beyond these limits. Bode's Law predicts a planet at a distance of 2.8 A. U. (astronomical units--92.9 million miles, or the average distance of the Earth from the Sun) from the Sun. In the year 1801, a small body was found to be going around the Sun in this particular space. Since that time over a thousand asteroids have been traced by astronomers. These asteroids have been found as small, thin streaks on telescopic long-exposure photographs. There are so many, in fact, that it is quite a problem to keep track of them. It is estimated that there are around 50,000 asteroids, ranging in size from small bits or chunks to Ceres, the largest, with a diameter of 480 miles (about one-fifth of the moon's diameter). Nearly all of the asteroids move in almost circular paths around the Sun in the same direction as the Earth, and near the same plane as the Earth.

Where did these chunks of matter originate? The first hypothesis was that a large planet exploded, or that two planets collided. If all the asteroids were in one mass, they would, perhaps, form one planet about the size of Mars. But since there is much space between the orbits of Mars and Jupiter, only two planets there would make it unlikely that they would collide. A near miss would only cause the two planets to swing around each other into two new orbits and not break them into many pieces. Another astronomical explanation is that the asteroids have always been there--since the very beginning of the Solar System. They might have kept colliding with each other to make smaller and smaller chunks and bits. Those chunks and bits might go off in different directions, then some of them would hit the earth, the other planets, and the satellites. If this is true, the impact would explain the craters on Mars, on the moon, and a few similar craters on the earth such as Barringer Crater in Arizona. These great collisions must be few and far between, because there have been no new lunar craters formed in the last hundred years.

Whatever the origin of the asteroids may have been, there is substantial information that the material from which they are composed is almost certainly the same basic elements as that of the other planets regardless of whether they are the debris of an unformed planet, or the remains of a planet destroyed, the asteroids are fragments of rock and metal of varied sizes.

CHAPTER IX

HOW ARE THE OUTER PLANETS DIFFERENT FROM THE EARTH?

Objectives:

1. If I were blindfolded and sent in a spaceship to one of the planets, how would I recognize my location after landing?
2. What are some of the different techniques for classifying the planets?

Jupiter, Saturn, Uranus, Neptune, and Pluto--are called the "outer planets" because their orbits lie outside the main zone of the asteroids. The four inner planets--Mercury, Venus, Earth, and Mars--along with Pluto are often called the terrestrial planets, because they are so small compared with the four major planets: Jupiter, Saturn, Uranus, and Neptune. In size alone the four giant planets are in a class by themselves. The Earth, with a diameter of nearly 8,000 miles, is very small when compared to Jupiter, which is 86,700 miles in diameter. Saturn is smaller than Jupiter, having a diameter of 71,500 miles; and Uranus and Neptune, each with diameters of about 29,000 miles, are approximately one-third the size of Jupiter, but still more than three times the size of the Earth.

9.1 Jupiter

Of all the planets, Jupiter is by far the largest, and is rightfully named for the "King of the Gods." Its diameter is more than eleven times the earth's, and its mass exceeds the mass of all the other planets combined. In 1610, Galileo discovered Jupiter's four largest moons, using the first telescope ever built. Additional ones were discovered from time to time until 1951, when Nicholson discovered the twelfth and smallest of Jupiter's family of satellites.

Jupiter seems to be banded with alternately bright and dark belts running parallel to its equator. These bands are features of the atmosphere and change slightly from time to time. Another prominent feature of Jupiter is the "Great Red Spot," a large oval spot about 8,700 miles wide and 30,000 miles long. This spot was first observed in 1878, and though it has lost some of its color over the years, its outline is still visible.

The average distance from Jupiter to the Sun is 483 million miles, and the planet travels with an average orbital speed of 8 miles/second, making one complete revolution in 11.96 Earth-years. Jupiter makes one complete rotation on its axis in an average of 9 hours 55 minutes in Earth time. This rapid rotation has caused it to become an oblate spheroid, flattened at the poles and bulging at the equator. The equatorial diameter exceeds the polar diameter by 5,760 miles. The planet appears flattened by a little over 6 per cent, a phenomenon easily noticeable with a moderate size telescope.

Three gases have been identified in the atmosphere of Jupiter--hydrogen, ammonia, and methane. Ammonia becomes a solid at -108° F., and the average temperature on Jupiter is -216° F.; thus perhaps some of the ammonia is frozen into solid crystals.

As previously mentioned, the inclination of the Earth's equator to the plane of its orbit is 23½°; for Jupiter this inclination is a mere 3°. This, along with the fact that Jupiter's orbit is very nearly circular, causes an absence of noticeable seasons. Since Jupiter receives only one twenty-seventh as much energy per unit area from the Sun as does the Earth, the frigid and unchanging Jovian climate is no surprise.

9.2 Saturn

The most distant of the planets known to the ancients was Saturn with its beautiful rings. Its mean distance from the Sun is 886 million miles, wherefore it takes the planet 29.5 Earth-years to make one complete revolution around the Sun. It appears bright yellow in colors, and its system of rings makes it one of the most impressive celestial objects to view with the telescope.

Saturn ranks second to Jupiter in size and mass, and its bulge at the equator is even more prominent than that of Jupiter. The polar diameter is 67,250 miles, and the equatorial diameter is 75,100 miles. The mass of the planet is 95 times the Earth's mass, and its volume is about 760 times that of the Earth. The mean density of Saturn is the lowest of all the planets, only 0.7 that of water.

An examination of their spectra reveals striking similarities between Saturn and Jupiter. Both atmospheres contain the same three gases--hydrogen, ammonia, and methane. The methane bands are stronger in the spectrum from Saturn, and the ammonia bands are weaker, presumably because the temperature is lower (-250° F. as compared to -216° F. for Jupiter). One notable difference is the inclination of

Saturn's axis to the plane of its orbit, 28°. This causes marked seasonal changes as far as sunlight is concerned (Jupiter, on the other hand, has no noticeable seasonal changes since its angle of inclination is only 3°).

Saturn has ten known satellites. Titan, the largest and brightest, is unique in that it is the only satellite in the solar system known to have an atmosphere; it resembles Mars in its reddish color, and its spectrum shows methane bands.

The most impressive feature of the planet is its system of three concentric rings. The entire ring system is 172,600 miles in diameter and only slightly more than 10 miles thick. The plane of the rings coincides with the plane of the equator of Saturn. These three rings are usually referred to as the outer, the middle (or bright) ring, and the crepe ring. The outermost ring has a maximum diameter of 172,600 miles and a width of 10,900 miles. Separating the outer ring and the bright ring is a gap of 5,900 miles called the Cassini division. The bright ring has an outer diameter of 146,000 miles and a width of 17,900 miles. The crepe ring appears as a continuation of the bright ring and extends inward a distance of 11,000 miles. Between the inner ring and the planet there is a gap of 5,900 miles. The crepe ring must be looked for with some care to be seen at all. Walter A. Freibelman of the University of Pittsburgh Physics Department has offered substantial evidence of a fourth and very thin ring that has an outer diameter of 340,000 miles.

He photographed Saturn through the 30-inch refracting telescope at the Allegheney Observatory during the period in 1967 when Saturn could be seen edge-on from Earth.*

From our distant vantage point, the light reflected from the rings gives the appearance of a continuous surface. A study of the spectrum suggests that the rings actually consist of solid particles revolving like satellites around Saturn. If the rings were continuous, all parts would have the same period of rotation, and the outermost part would have the greatest speed since it would have the farthest to go. The spectrum shows, however, that the innermost part has the fastest motion--a necessary condition if the rings are composed of separate pieces.

9.3 Uranus

Uranus was the first planet to be discovered by man, the scientist. In 1781 William Herschel was using a small 6½" reflector telescope to examine a region in the constellation Gemini when he noticed an object that was somewhat different from the ordinary star. After many hours of regular nightly observation, he determined that it was in motion with respect to the stars in the field. He immediately announced that he had discovered a new comet. After he spent months diligently following the object and trying to calculate an orbit, it proved to be a new planet twice as far from the Sun as Saturn.

* This means that the plane in which the rings lie, if extended, would bisect the Earth.

Uranus, as the new planet was ultimately named, is nearly 30,000 miles in diameter and revolves around the Sun once in 84 Earth-years. The period of rotation cannot be determined by direct visual methods because of the absence of definite surface markings. It can be determined, however, by spectroscopic methods: a period of 10 hours and 49 minutes.

The spectrum of Uranus shows absorption bands of methane and possibly some molecular hydrogen. The average temperature is about -300° F.

The planet has five satellites revolving around it in nearly circular orbits. Two were discovered by Herschel in 1787, two by Lassell in 1851. The fifth and faintest was not discovered until 1948, by Kuiper at McDonald Observatory.

9.4 Neptune

As previously mentioned, Uranus was discovered quite by accident. Neptune, by contrast, was found as the result of mathematical prediction. Several decades after its discovery, the orbit of Uranus was calculated from observations of its motion. But it was found that the planet did not precisely follow its predicted orbit even as modified by the gravitational effects of Jupiter and Saturn. By 1840 many astronomers were convinced that the reason for this discrepancy was the action of an unknown planet or planets more remote than Uranus.

In 1845 Leverrier, a French mathematician, became interested in the problem, and in 1846 he published calculations predicting the location of this new and theretofore unknown planet. Leverrier convinced Galle, an astronomer at the Berlin Observatory, that he should look for the new planet. The first night he looked for it, Galle discovered the planet Neptune within 50 seconds of the position predicted by Leverrier's calculations.

Neptune revolves about the Sun in an almost circular orbit at an average distance of 2,797 million miles. Its diameter is not easily measured, but it is probably about 33,000 miles. Its period of revolution is 165 years; therefore, it will not complete the first revolution since its discovery until 2011.

Neptune has two satellites. The larger, Triton, is somewhat larger than our moon, and there is some evidence that it has an atmosphere. The second is very small and was discovered by Kuiper in 1949.

The spectrum of this planet shows greater methane absorption bands than that of any of the other planets. The temperature of the observable surface is in the neighborhood of -330° F. At this temperature most substances would be frozen out of the atmosphere.

9.5 Pluto

Even after the discovery of Neptune there remained slight discrepancies between the observed and the predicted orbit of Uranus, suggesting another planet even farther from the Sun. As early as 1905 a telescopic search for this unknown planet was inaugurated by Percival Lowell. Lowell died in 1916, but members of the staff at Lowell Observatory intermittently continued the search for this unknown planet. On March 13, 1930, Clyde Tombaugh discovered the planet now named Pluto.

Pluto is an average distance from the Sun, 3,670 million miles. Its diameter, as measured by Kuiper on the 200-inch Itale telescope, is 3,600 miles. It revolves around the Sun once in 248 Earth-years. The orbit of Pluto departs from a circle much more than that of any of the other planets; thus its distance from the Sun varies enormously. At apogee it is 1800 million miles farther from the Sun than Neptune. When Pluto is at perigee, it is 35 million miles closer than Neptune.

Pluto is thought to have a gritty, snow-covered surface and no atmosphere. The temperature on Pluto must be lower than that on Neptune, possibly below -350° F. The planet would have to be about 4000 times brighter to be visible to the unaided eye.

Activities

1. Comparing the distances of planets from the Sun

Objective: To locate the Earth's position in the Sun's family or solar system.

Discuss with the students the nine known planets in our solar system. Ask members of the class to find the distance of each planet from the Sun. Discuss what would probably be a fairly logical scale of miles so that proportionate distances could be measured in the school's neighborhood. (It might be suggested that one inch could equal one million miles).

Next measure the distances of the planets away from a central open spot, and then, with the help of students, mark the position of each planet as near as possible. Ask a student to stand on each mark representing a planet. The students who represent the various planets might make signs telling the names of the planets. Appoint another student to be the Sun. Then have the "human planets" walk around the Sun, keeping within the limits of their respective orbits and velocities.

Observations: It will be realized by the students that the farther the planet is from the Sun, the longer it takes to make a complete revolution. By using the method just described, the students can visualize the nine planets in the solar system.

2. Simulating the surface of the Moon

Objective: To show that much is yet to be known about the moon's surface, but that it does have some definite characteristics.

Materials needed: Plaster of Paris, Marbles, Sand and Gravel, Water, Aluminum pie plate, Rocks

Ask a student to drop marbles or rocks (which represent meteorites) in the pie plate of dry plaster of Paris. Notice the types of craters that result. Ask the students if these formations look similar to the moon's surface.

Next, mix enough water with plaster of Paris to make a thick, creamy mixture in the aluminum pie plate. Stir vigorously until bubbles appear, then let the mixture harden. Where these bubbles have burst is there a resemblance of volcanoes?

Next, mix sand and gravel with water-thickened plaster of Paris and let it harden. Ask the children if they think that the moon's surface might resemble this mixture.

Observations: At the present, little is known about the moon's surface, except that it is pox-marked with craters, and that soft and powdery as it may seem, it may be hard and rocky.

3. Make scale models of the planets. These may be made from styrafoam balls, balls covered with papier-mache, or any other suitable substance which might be colored.

4. Make posters of the planets depicting the characteristics of each.

5. Demonstrate the rotation of the earth on its axis.

   Objective: To show that the earth rotates on its axis.

   Materials needed:

   A G-clamp with a ball bearing soldered to the inside of the jaw makes a good support for a Foucault Pendulum. It is best hung indoors resting on a razor blade or some other hard surface. When such a pendulum is set in motion, the plane of swing is altered after a few hours, as will be noticed if a mark is made on the floor at the time of release. It is, of course, the earth rotating underneath the "bob" which gives this effect.

6. Prepare written or oral reports on the planets and asteroids.

7. Write science fiction stories on imaginary trips to various planets or the moon, using facts we have to date about their various features, plus your imagination.

8. Prepare reports, written or oral, about Galileo and Jules Verne.

9. With the aid of weekly or monthly sky maps published in Sky and Telescope or newspapers, locate the planets currently visible as they are being studied (February is an excellent month to view the planets). Observe their changes of position on successive nights. Notice differences in their appearance to the unaided eye; also, if possible, when using a telescope or good binoculars.

10. If possible, take the class on a visit to a planetarium and observatory at the close of the study of the planets and the moon. Before going on this trip be sure that students know what is to be observed and, perhaps, have the students prepare some questions to ask those in charge of the planetarium or observatory. As to follow up activity in the classroom, ask each student to make a written report of the trip, telling what interested him most.

CHAPTER X

THE MOON

WHAT IS THE MOST SPLENDID OBJECT SEEN IN THE ENTIRE NIGHT SKY?

Objectives

1. How are things on the moon different from things on Earth?
2. How does the revolution of the moon affect us on Earth?
3. How can I measure the size of the moon?
4. How do we know how far it is from the Earth to the moon?

10.1 What is the distance of the moon from the Earth?

The average distance between the moon and the Earth is 240,000 miles with an apogee of 252,710 miles and a perigee of 221,460 miles. In order to envision how far this is approximately make the following comparison. The distance across the United States is about 3000 miles. A passenger in a jet plane travels this distance in less than eight hours. The distance between the Earth and the moon would be comparable to making forty round trips across the United States. Everybody who is ready to embark upon a non-stop thirteen day airplane ride, climb aboard.

The distance around the Earth is 25,000 miles. If you traveled around the Earth ten times you would travel a distance equal to the distance to the moon from the Earth. If you want to compare the distance by considering the size of the Earth you would have to stack 30 Earths on top of one another, since the Earth is 8,000 miles through from pole to pole.

10.2 How big is the moon?

The moon is 2,160 miles in diameter. This is more than a quarter of the Earth's diameter, and the moon's mass is 1/82 as much as the Earth's mass. The mass of a body is the total amount of matter contained within it. Not only is the moon's mass lower than the Earth's, but it is also much less dense than the Earth. The density of a body is the amount of mass per unit volume. To understand this better think of a pound of cotton and a pound of iron. Both have the same mass, but the density of the iron is much greater.

If you mixed all the materials from which the moon is made in one batch and all the materials from which the Earth is made in another batch and took a sample of each, the moon sample would weigh only 60 per cent as much as the equal volume of the Earth's sample. This would lead us to believe that the moon has no heavy iron core similar to that which gives the Earth its high density (5.5 times that of water). The density of the moon is just 3.3 times that of water.

10.3 What is the moon's temperature?

Since the moon rotates once per revolution about the Earth, one particular point of the moon is in sunlight for two weeks, then in darkness for two weeks. In the center of the full moon the surface temperature is about 270° F. About two weeks later, at lunar midnight, the temperature drops to about -240° F. When the moon enters the Earth's shadow during a total lunar eclipse the temperature drops very quickly. This leads scientists to believe that the heat conductivity of the lunar surface material is very low and probably very porous.

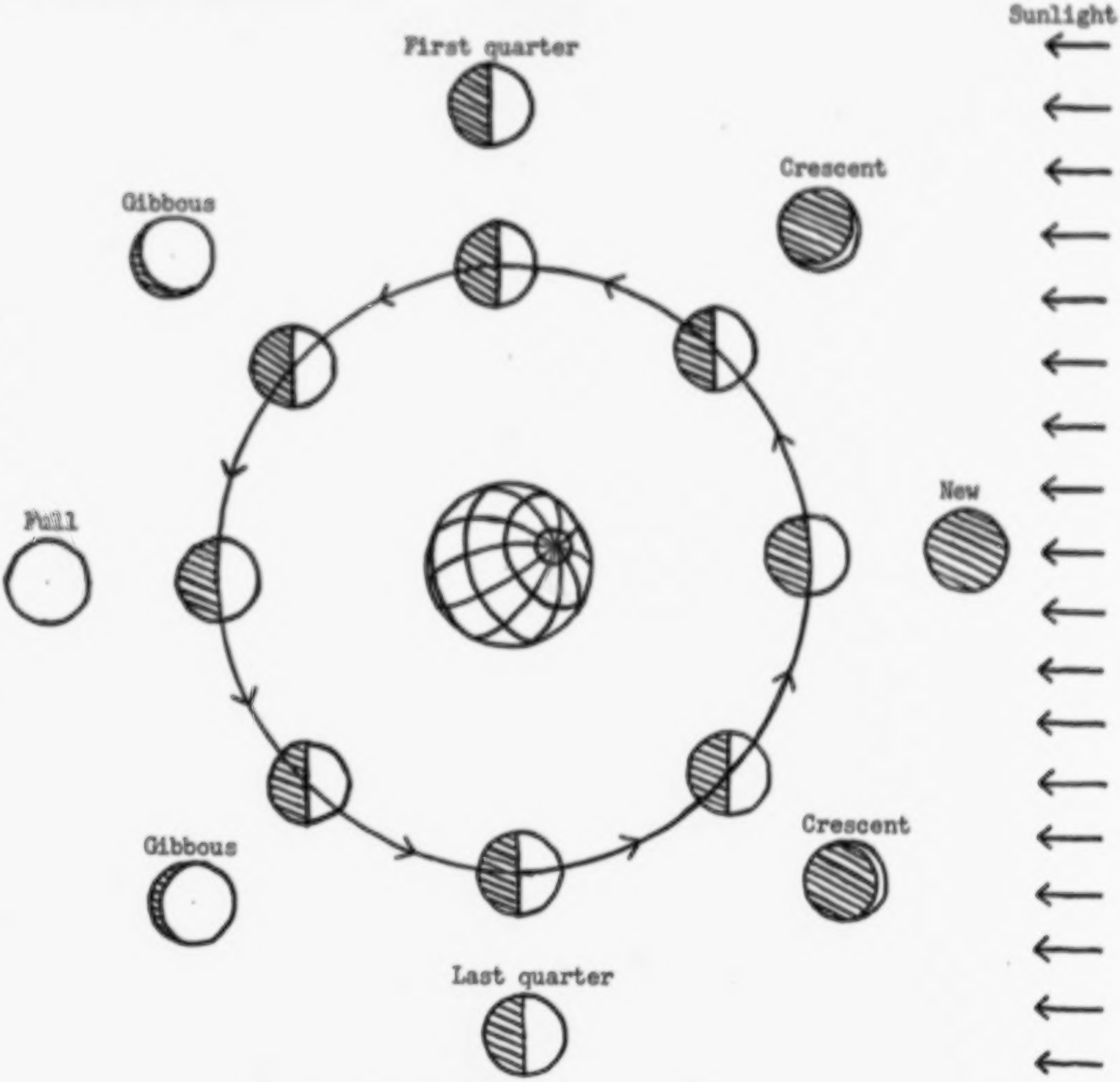
10.4 What causes the moon to rise and set?

Because of the rotation of the Earth on its axis from west to east, the moon appears to rise and set. As the Earth moves toward the east, everything in the sky seems to move toward the west. Because of the moon's orbital revolution around the Earth it also has an eastward motion. In a one day period the moon will have moved a distance equal to about twenty-four times its width, or about 12 degrees in the sky. As a result the moon will rise a little later in the sky each night.

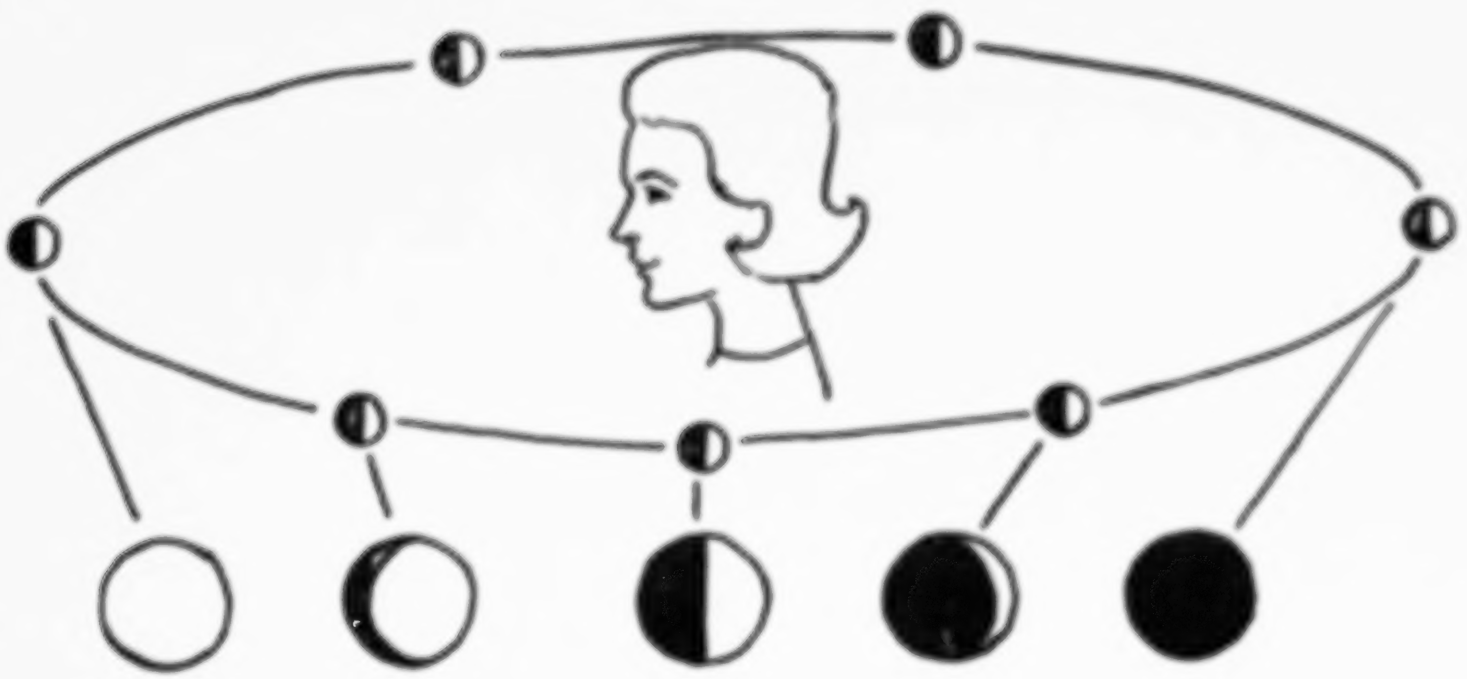
10.5 What causes the different phases of the moon?

There are different phases of the moon because of the motion of the moon around the Earth and because moonlight is reflected sunlight. The different shapes are caused by the amount of the moon's sunlit hemisphere turned toward the Earth. We see the "new moon" in the western sky after sunset when the majority of the dark hemisphere of the moon is toward us. As the moon progresses eastward in its orbit the crescent continues to grow until it has moved a quarter of the distance around from the Sun in its orbit. At this point we see just half the disk of the moon that is turned toward the Earth. This we call the "first quarter" of the moon. After this phase, the moon gets a sort of lopsided appearance, which is called the "gibbous" phase.

As the moon continues in its orbit we gradually see more of it until the whole daylight side of the moon is toward the Earth. We call this phase the "full moon." Subsequently the phases are repeated in reverse order, full moon, gibbous moon, quarter moon, and crescent moon.


Sunlight
First quarter
Crescent
Gibbous
New
Full
Gibbous
Crescent
Last quarter

PHASES OF THE MOON



What the student sees

Problem: What causes the moon's phases?

Materials: Bi-colored ping pong ball (black and white)

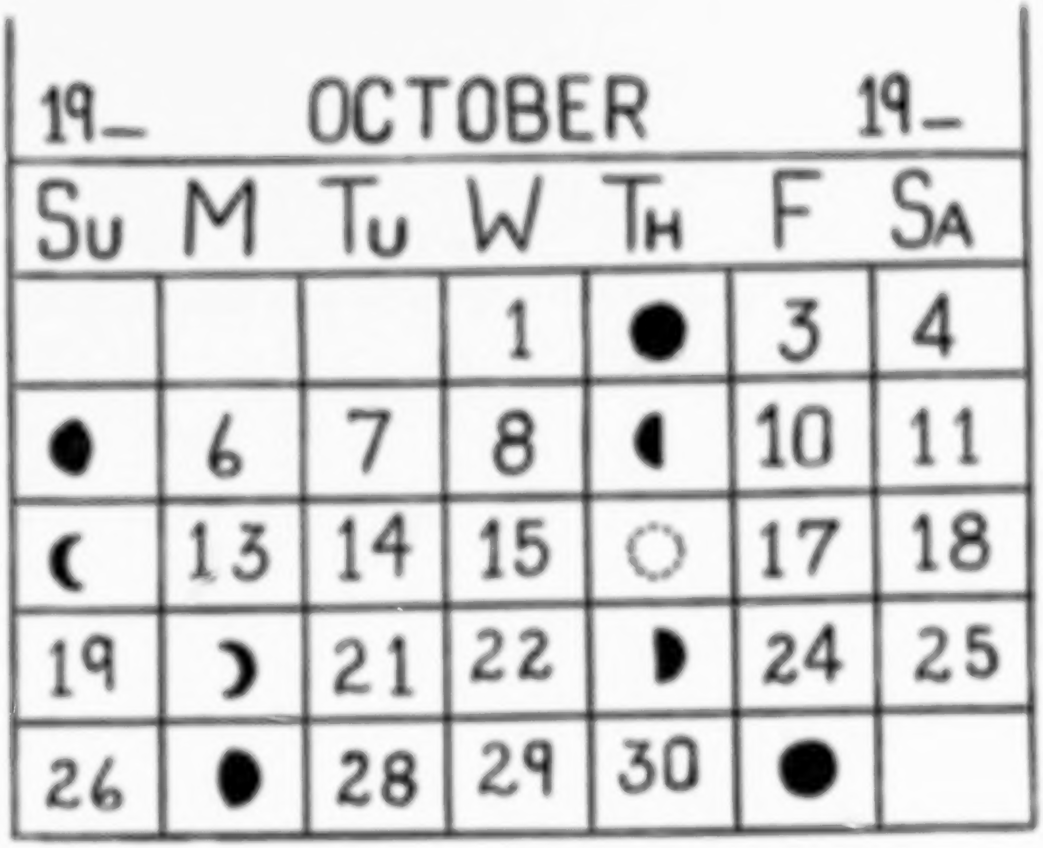
Procedure:

1. Imagine that the Sun's position is behind you.
2. Hold ping pong ball above and in front of you with the white side toward you.
3. While holding the ping pong ball at arm's length, move it counter clock wise until it is at right angles to your head and to the Sun's position behind you.
4. Since rotation time equals revolution time, the moon in this right angle position has only one half of its white side visible. The black surface represents the invisible part of the moon.

5. Continue to move the "moon" until it gets to a 45° angle in relation to your head and the Sun. Notice that the white portion visible in this position is crescent shaped (you will have to turn you head to see).
6. Continue moving the ball until it is directly behind you. The black portion of the ball is now toward you and since, in this position, you would be looking directly into the Sun, the moon is invisible.
7. Continue moving the ball (look over your right shoulder now) and notice the opposite pointed crescent and other phases.
8. Give alternate pupils bi-colored ping pong balls and have them alternate in teaching one another the phases of the moon. This is sometimes called the "coach and pupil" method.
9. Holding a ping pong ball near a globe, determine how it is possible to see the moon during daylight hours and also why we see no moon at certain times of the month.

Source: Thaw, Richard F. and Morlan, John E. Experiences and Demonstrations in Elementary Science. Dubuque, Iowa: Wm. C. Brown Co., 1964. p. 19.

Activity on Moon Phases



19_			OCTOBER			19_
Su	M	Tu	W	Th	F	Sa
			1	●	3	4
●	6	7	8	◖	10	11
☾	13	14	15	○	17	18
19	☽	21	22	◗	24	25
26	●	28	29	30	●	

To help children get some idea of the regularity and reason for the moon's phases, have them observe it each evening. Cut out its shape each day and fasten it on a calendar. The number of days between a "half" moon and a "full" moon will be the same as between a "new" moon and a "half" moon. A "half moon" that curves one way will be followed by one that curves the opposite way. Once the children have begun to observe and record these phases, they will be ready for activities with a tennis ball and flashlight.

A most unusual feature of the moon is the thousands of craters of varied sizes which are spread over the entire visible surface. These circular depressions have walls surmounted by lofty mountain peaks. The space within the mountain wall is known as a lunar crater. The rounded shallow pits are fairly level, except where lumps of mountain peaks rise near the center of many of the craters. The craters range in size from less than a mile to nearly 150 miles in diameter. Crater walls may be as high as 30,000 feet above the floor. The larger craters are called great walled plains. Many of these lunar craters are named after famous scientists and philosophers of former times.

The origin of the craters is a mystery. Some astronomers think they were caused by meteors colliding with the moon's surface. Another theory is that volcanic action caused huge gas pockets to push up to the surface and erupt, leaving craters as round scars. There is good evidence to support both ideas, and the question as to their origin will probably not be answered until man visits the moon and explores its surface.

What do we mean when we say the "new moon is in the old moon's arms?"

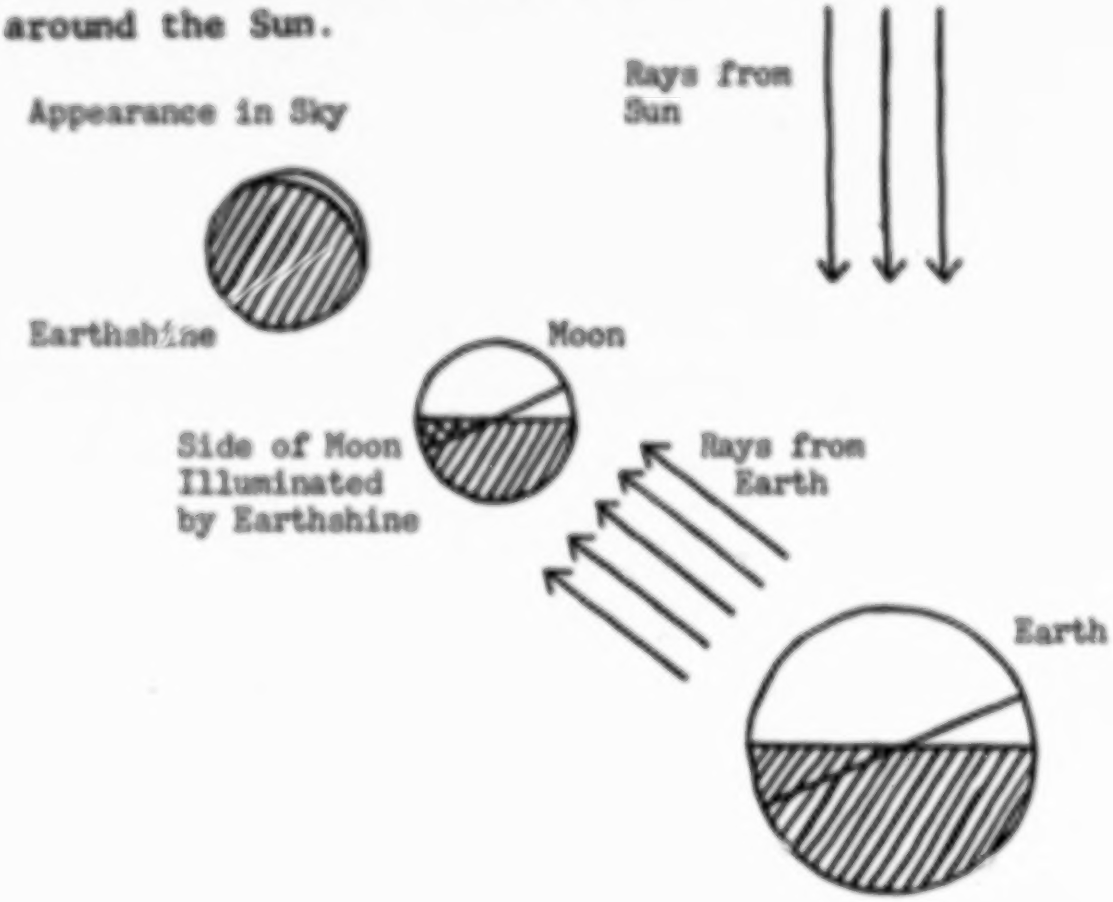
This is most clearly seen when the moon is in the crescent stage. In actuality it is the reflected light from the Earth falling on the moon and being reflected back to

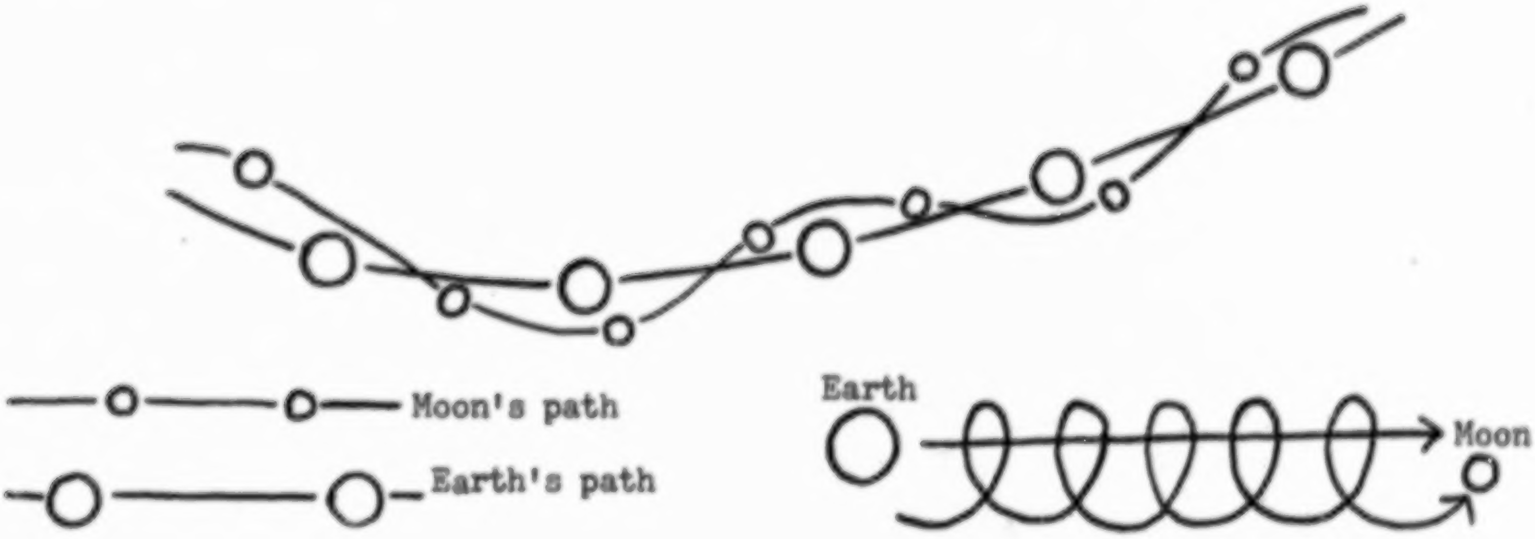
Earth again. The crescent moon is illuminated by the Sun but the rest of the moon shows as a bluish disk giving the appearance of "the new moon in the old moon's arms." (See p. 27 Richardson - Astronomy)

10.6 Why is the same side of the moon always toward us?

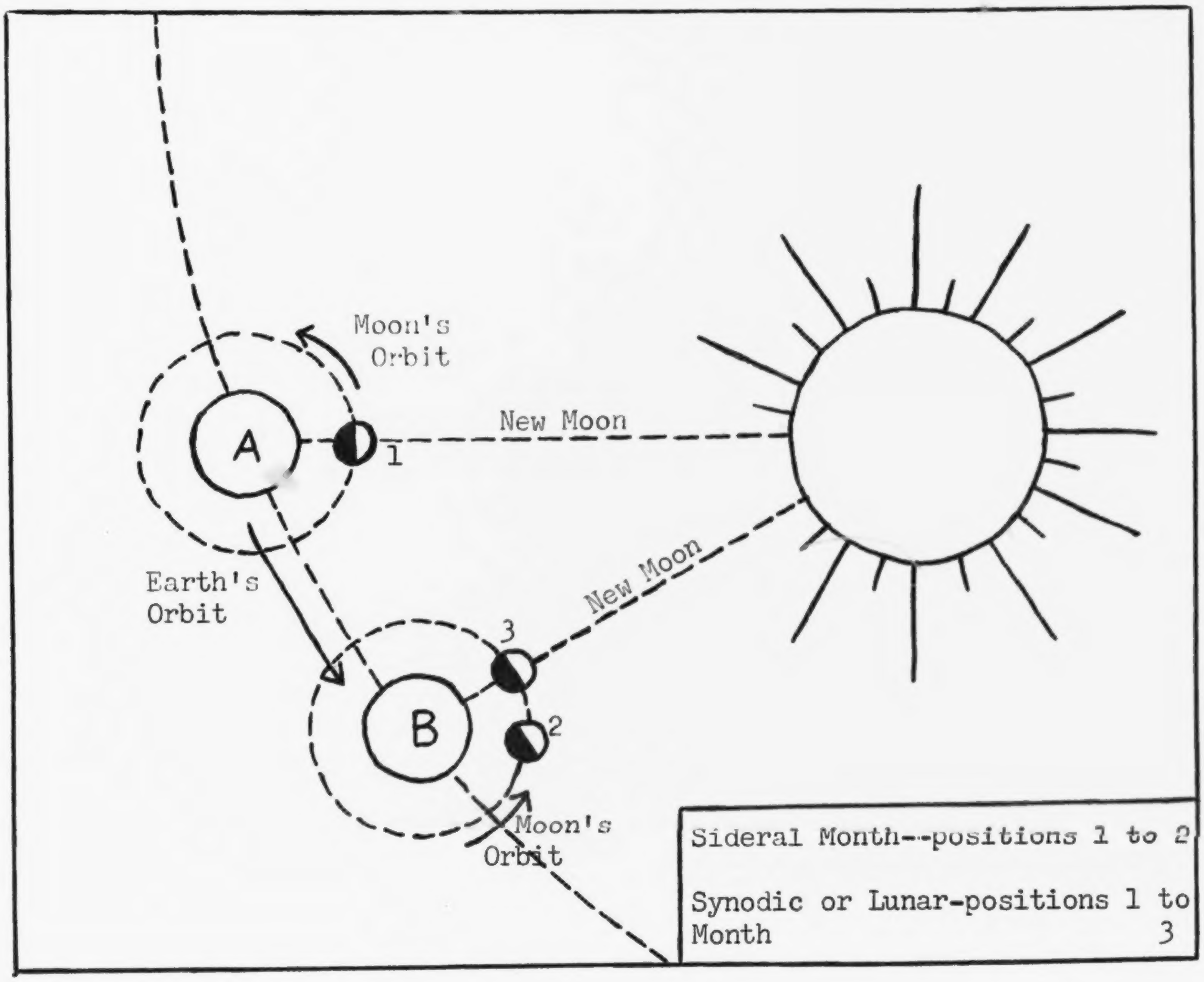
Contributing to the discomfiture of curious people, who always want to know what's on the other side of the hill, is the fact that the moon always has its same side toward the Earth. The explanation for this phenomenom is the observation that the moon rotates on its axis at approximately the same average rate as it revolves around the Earth. Although the moon rotates at a steady rate on its axis, it does not revolve at a constant rate in its orbit. Therefore, during the month the moon's rate of revolution does not keep exactly in step with its rate of rotation. When the moon is nearer the Earth it moves faster than when it is farther from the Earth. Because of the variation in the rate of revolution, we occasionally see a small part of the moon that is usually hidden.

The moon takes 27 1/3 days to complete its revolution around the Earth. This period is called the sidereal month. However, in 27 1/3 days the Earth has moved 1/12 of its orbit around the Sun. For this reason it takes 29½ days for the moon to make an appearance of the same phase. (From new moon to new moon). This 29½ days is called the synodic month or the days between new moons. Since the Earth and the moon are both revolving around the Sun it takes over two days more for the moon to catch up with the Earth's revolution around the Sun.


Appearance in Sky
Rays from Sun
Earthshine
Moon
Side of Moon Illuminated by Earthshine
Rays from Earth
Earth


Moon's path
Earth's path
Earth
Moon

The Moon's Timetable


Moon's Orbit
New Moon
A
1
Earth's Orbit
New Moon
3
B
2
Moon's Orbit
Sideral Month--positions 1 to 2
Synodic or Lunar-positions 1 to 3
Month

Compton's Pictured Encyclopedia and Fact Index, Vol. 9.
Chicago: William Benton Publisher, Compton Co. p. 483.

10.7 Does the moon have an atmosphere?

Scientists feel quite safe in proposing the idea that the moon has no atmosphere. Continuous and prolonged viewing of the moon has verified the fact that its surface is never obscured by clouds, haze, or storms such as those which commonly hide the Earth's surface from observation by a pilot flying high above. At the edge of the moon where an atmosphere should be thickest, the surface of the moon is as clear as the center. There is no twilight on the moon such as the Earth has--only a sharp division between night and day.

The most accurate proof of the nonexistence of an atmosphere is provided when the moon occults a star. An occultation occurs when the moon passes in front of a star. If the moon possessed an atmosphere the star would fade gradually as its light passed through more layers of the moon's atmosphere. However, this is not the case. The star disappears very abruptly. One minute you can see it, the next minute it's gone. As the moon moves on the star reappears as abruptly as it disappeared. Because the moon has no atmosphere, it is also theorized that it has no life.

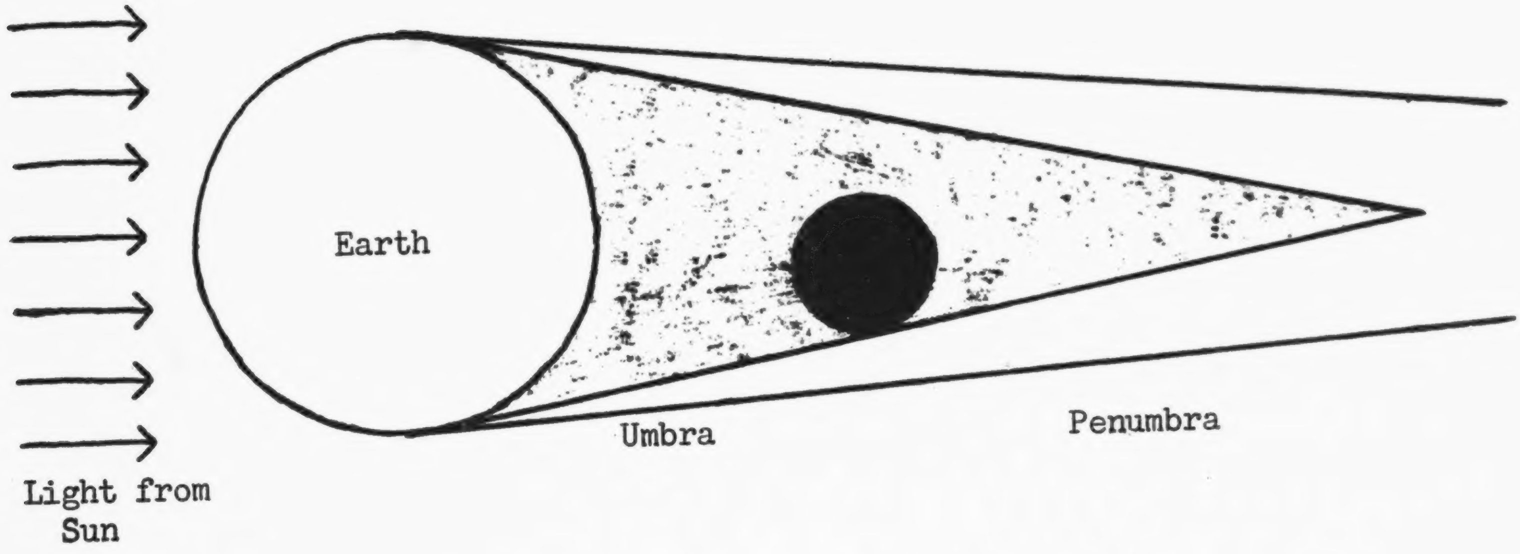
10.8 What causes an eclipse of the moon?

An eclipse of the moon occurs when the moon passes into the shadow of the Earth. Since the moon's orbit is not in the same plane as the Earth's orbit, the shadow cone passes a little above or below the moon many times, and no eclipse occurs.

Although eclipses of the Sun occur more often than those of the moon, we see many more eclipses of the moon than we do of the Sun. The reason for our observing fewer eclipses of the Sun is that the tip of the moon's shadow, when it reaches the Earth, is so small that it covers only a very small spot on the surface of the Earth--never more than 167 miles wide. Therefore, only a few people within this narrow path will see the Sun in total eclipse. An eclipse of the moon is visible to everyone on the right side of the Earth. An eclipse of the moon lasts much longer than a solar eclipse. The longest duration of a solar eclipse is 7 minutes and 40 seconds, while a total lunar eclipse may last for as much as 1 hour and 40 minutes.

The shadow of any opaque object in the sunshine consists of the *umbra and penumbra*. The Earth's umbra is a long, thin cone reaching an average of 859,000 miles into space before it tapers to a point. This darker part of the shadow is generally spoken of as the shadow of an object. It is surrounded by the penumbra, for which the direct sunlight is partly excluded.

Total Eclipse of the Moon


Earth
Umbra
Penumbra
Light from
Sun

Activity

1. With a flashlight and two clay balls to represent the Earth and moon, show how an eclipse of the moon occurs, also show why there is not an eclipse of the moon every orbit of the moon.

10.9 How does the moon affect the tides?

The moon's gravitational attraction provides the energy for tides. The moon revolves around the Earth because the Earth has a gravitational pull on it. The moon also exerts a continuous gravitational pull on the Earth. The part of the Earth that is nearest the moon is pulled on more than the part that is farthest from the moon. As the moon pulls on the Earth, the water and the land bulge toward the moon. The land being firm is not moved much, but the water bulges quite a bit. When this happens we get high tides. As the Earth turns, the part of the water that is nearest the moon will be at high tide, while the water that is 90°, form a perpendicular line between the Earth and moon at low tide.

Since the moon crosses the meridian nearly an hour later each day, the high tide comes nearly an hour later each day. At the new moon and the full moon the tides are the highest. Also, the shape of the coastline and the depth of the water will help determine how high the tides get. Tidal range is typically from 3 to 10 feet.

10.10 How do we determine the distance to the moon?

Triangulation is a means of determining distances. In order to use triangulation it is necessary to measure three particular parts of a triangle, such as two angles and the side between them. When the size of these three particular parts are known, the sizes of the other three parts can be computed.

Activities

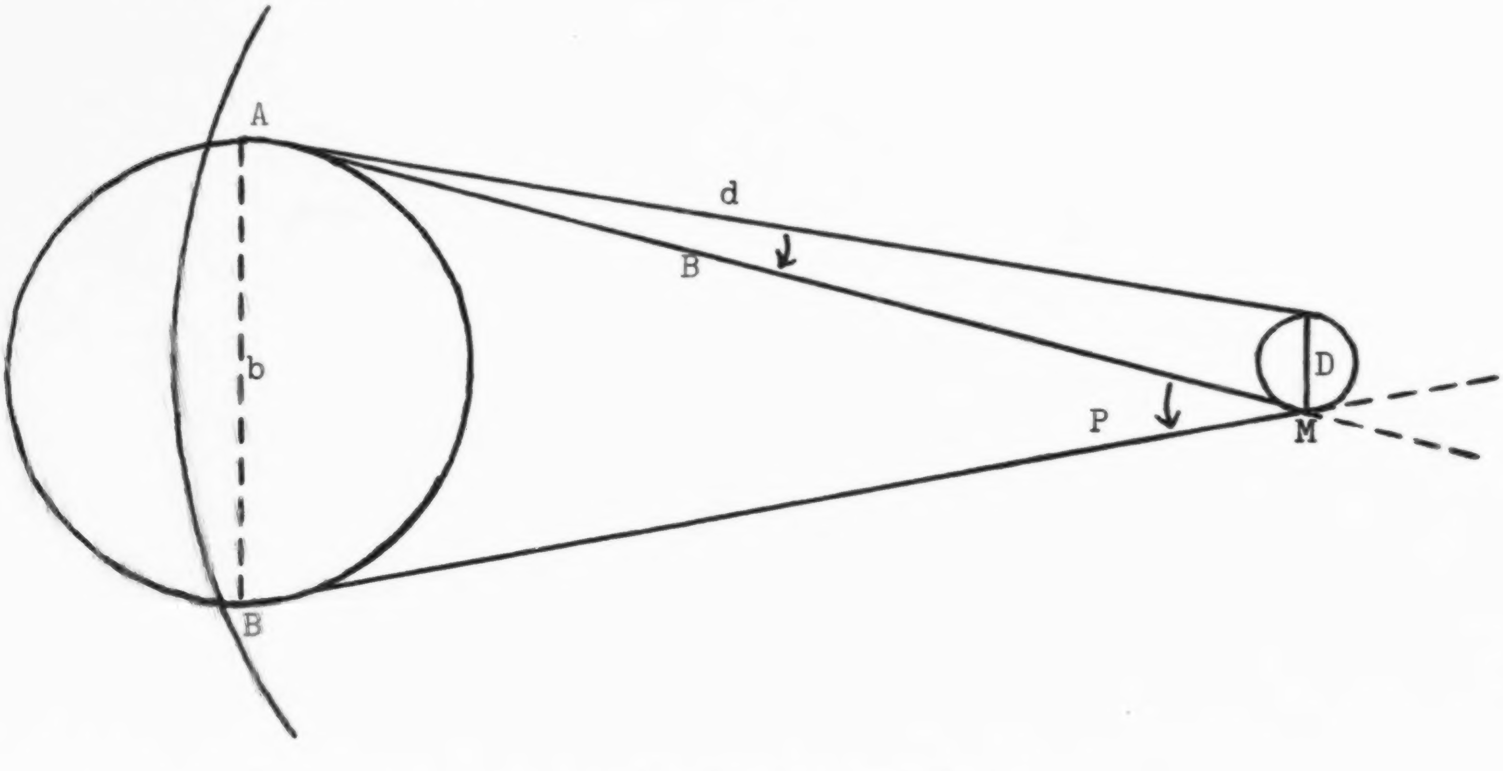
Materials needed:

- Table
- Yardstick
- Soda Straws
- Pins
- Paper
- Pencils

Using a table (preferably outside) have two children stand two feet apart on one side of the table. Have them take a straight pin and insert it through the middle of a straw. Then pin the straw to the yardstick at the 6 inch and 30 inch marks. Put the yardstick with the straws on the table between the children. Have the children sight through the straws toward a tree or some particular object. When they have focused in on the object measure the angle between the soda straws and the yardstick with a protractor. This gives you the measurement of 3 parts of the triangle.

Take these measurements and by using a scale of 1 inch to 1 foot have the children work the problem on paper. Using a ruler draw a 2 inch base line. Have them take their protractors and make the same angles that were obtained when the object was sighted through the straws. Using these angles, have them draw a line from each end of the base line and extend the lines until they intersect. Then measure the distance from the point of intersection to the 2 inch base line. By using the same scale, 1 inch being equal to 1 foot have them determine how many feet it was to the object they had focused on. To check their calculations, actually measure the distance. Be sure the children understand that by use of triangulation, the distance from an observer to an object can be measured without the object being within reach.

The following diagram, without going into the complexities of formulation may be useful to put on the bulletin board. (P. 118, The Astronomical Universe)



HOW DO WE FIND THE DIAMETER OF THE MOON?

Scientists use the triangulation formula for finding the diameter of the moon.

$$d = \frac{3438 \times D}{B}$$

To find D, the moon's linear diameter, you would solve the following equation.

$$D = \frac{B \times d}{3438}$$

The moon's angular diameter B is 31'5".2 at its mean distance of 238,850 miles. With this information we can determine that its linear diameter is

$$D = \frac{31.087 \times 238,850}{3438} = 2160 \text{ miles}$$

Thus, the moon's diameter is only 27 per cent of the Earth's; which means it only has 7.4 per cent as much surface area as the Earth and only 2 per cent as much volume. Why is this so?

Additional Activities

1. Have the children make a chart listing the different questions they have about the moon. Then have them do research to find the answers to the questions. (Questions can be answered through reading, experimenting, measuring, etc.)
2. A papier-mache moon can be made which shows craters and other features. The names of the "seas" may be written on the model in ink.
3. A bulletin board can be made to show different phases of the moon. (see illustration)
4. Make two field trips to an observatory. Remember that more can be seen of the moon when at its crescent phase than during its full phase.
5. Buy puzzle of the moon at Sears and have class work on it during spare time.

6. Reports on different aspects of the moon can be worked on individually.
7. Compare some of the older theories with more recent theories about the moon.
8. Send to NASA and get their moon packet. They also have films, booklets, pictures, etc. that you can acquire.
9. If you're lucky you might even get an astronaut to talk to the class.
10. Write to NASA Houston, Texas and they will send you all kinds of information on the moon and other things.

CHAPTER XI

What are some of the more familiar objects in our sky other than the planets?

Objectives

1. How does the Sun compare with other stars?
2. How can I study the chemical composition of the Sun?
3. Do sunspots affect me in any way?
4. What would happen if a comet ran into the Earth?
5. How do we know the Earth is increasing its mass each day?

11.1 The Sun

The Sun is just one average-sized star among the billions of stars in the universe. To us it is unique: the star around which the Earth revolves and to which it is held by gravitation. Its nearness to us provides us with life-supporting energy.

The Sun is a bright yellow star with a diameter of 864,000 miles. If it were hollow, over a million Earths would easily fit inside. The average density of the Sun is about one-fourth that of the Earth. The average temperature on the Sun's surface is about 5,500° C., while the temperature at the very center is estimated to be about 13,000,000° C. At this great temperature, the hydrogen from the Sun is changed into helium. Over four million tons of the Sun's matter is changed into energy every second. This process has been going on for billions of years and will continue for billions more.

The surface of the Sun is called the photosphere. It is speckled with bright patches and with dark sunspots. The Sun's atmosphere, or chromosphere, occurs above its photosphere. It is made of glowing hydrogen and extends about 5,000 miles above the photosphere. Solar prominences are great flame-like clouds of gas that extend as high as a million miles above the Sun's surface. The corona is the outer atmosphere that surrounds the Sun to a height of hundreds of thousands of miles. The corona changes size and shape and glows with a faint pearly light that is invisible except during a solar eclipse. Irregular dark spots often appear on the photosphere. These sunspots seem to be storms on the Sun's surface. The gases in the sunspot are cooler than the gases on the Sun's surface; therefore they appear darker.

A. How does our Sun compare in size and brightness with other stars?

Our Sun is 864,000 miles in diameter, its mass is 6.6×10^{23} tons, and its density is ¼ that of the Earth or about 1.4 times as dense as water. If we consider our Sun as 1 unit for diameter, mass and density, then:

	Smaller Star	Larger Star
Diameter	1/100	1,220
Mass	1/60	1,000
Density	10,000.000	1/10,000,000

The brightness of a star is determined by comparing the apparent brightness of that star with the Sun, were they placed the same distance from us. When the Sun is considered to have a brightness unit of 1, the following would be true on the same scale.

Faintest Visible Star	Brightest Visible Star
1/290	3.6

B. How do we know the temperature of our Sun?

By measuring the wavelength of color that is given off in greatest amounts, we know the temperature of the Sun. It is about 10,300° F.

Experience: The following experiment may serve as an example of this temperature determination. Heat an iron wire at varying distances from a flame. Notice that as the wire gets closer to the flame, its color changes from dull red to orange, yellow, and finally white.

Experience: Focus strong sunlight through a prism to produce a spectrum. Measure the temperature in various parts of the spectral range. (Be sure to include the ultraviolet and infrared sections of the spectrum). The temperature of a "perfect radiator" can be determined from the wavelength of the most intense radiation, as a consequence of Planck's Law, by the relation known as "Wein's Law":

$$T = \frac{28.9 \times 10^6}{\lambda m}$$

Where T is the temperature in degrees Kelvin, λm is the wavelength of the maximum radiation in Angstroms, and 28.9×10^6 is a constant determined by the units involved.

The most intense wavelength measured from the Sun's spectrum is 4750° A. Thus the effective temperature is

$$T = \frac{28.9 \times 10^6}{4750} = 6150^\circ \text{ K.}$$

C. How do we study the chemical composition of the Sun?

We can determine the composition of the Sun by an analysis of its spectrum.

Experience: Have students observe spectra of a neon glow light. (See Activity 82, p. 88, "Energy in Waves" in Investigating Science With Children)

In 1814 Josef Fraunhofer noted the spectrum from sunlight was crossed with "an almost countless number of strong and weak vertical lines"; then in 1859 Kirchoff stated the general laws connecting the emission and absorption of light, implying that the Fraunhofer lines are due to the absorption of certain wave lengths by the Sun's atmosphere. From observations on emission and absorption we may be able to determine what elements exist in the Sun, if we can find elements on Earth which will give bright lines, on emission, at the same wave lengths as the dark Fraunhofer lines in the solar spectrum.

D. What are some characteristic features of the Sun's surface?

Sunspots, prominences, corona, and flares are among the characterisitc features of the Sun's surface. A sunspot is a less bright depression on the surface of the Sun, similar to the eye of a cyclone, where a magnetic force has inhibited normal convective circulation and thus created a relatively cool spot. Sunspots are usually found within 30° of the solar equator.

A solar prominence is a condensation, or "cloud," within the corona. They are typically from 18,000 to 60,000 miles high, more than 100,000 miles long, but only 3,000 miles thick. A solar flare is a sudden outburst of light from the Sun's surface which lasts from 4 minutes to 7 hours.

E. How do we know there are strong magnetic fields in solar prominences?

The Zeeman effect occurs when spectral lines are split by the presence of a strong magnetic field. Observations of spectral lines originating from the Sun, clearly depicts splitting and leads us to the conclusion there are strong magnetic fields in solar prominences.

F. What is the source of the Sun's energy?

The energy of the Sun comes from the conversion of matter to energy in a thermo-nuclear reaction. The quantitative relationship existing between matter and energy is described by Einstein's equation, "$E = mc^2$."

G. Will the Sun burn itself out?

If the Sun continues to convert hydrogen into helium at the present rate, then it is possible that the Sun could burn itself out in about 5 billion years.

11.2 Comets

Comets are generally regarded as among the most spectacular heavenly bodies. About five or ten comets appear yearly, but most are faint telescopic objects. Records of comets, which often caused terror in ancient times, go back at least 25 centuries .

The photograph of a comet shows a glowing head and a long luminous tail. The head appears to have a bright small nucleus surrounded by a hazy coma. The nucleus is believed to be a loose spongy mass of icy material about one mile in diameter. Billions of tiny particles of rock are frozen into the "ice," which is largely frozen water, ammonia, and methane. Comets shine partly by reflected light, partly because sunlight causes their own gases to flow. Comets' tails consist of exceedingly fine gases and dust, expelled from the heads of the comets. The tail may be so tenuous that stars shine through it with undiminished brightness. A comet's tail always streams away from the Sun, and as the comet recedes from the Sun the size of the tail decreases. Most comets lack a spectacular tail; but in a few it develops rapidly and may become hundreds of millions of miles long.

Comets were once believed to be visitors from outer space, but now they are recognized as members of our solar system which move around the Sun in definite orbits. Comets seem to be closely related to meteors and asteroids.

A. How are comets different from other heavenly bodies?

Comets are: irregular in form, variable in dimensions, discontinuous in structure, very low in density and mass, luminescent as well as reflecting, and they are not permanent. Comets have a fuzzy head or "coma," a star-shaped nucleus imbedded in the head and a long gaseous tail.

B. How large are comets?

The nucleus, from which the head and tail are derived is usually only a few miles across, but in a few comets it may be as large as 100 miles.

The average head has a diameter of 80,000 miles, but the size may be 10,000 miles to 1,400,000 miles.

Most comets do not have tails, but where these exist they may be as long as 180,000,000 miles.

C. How do we know the mass of a comet is very small?

The observable existence of tidal disruption in the nucleus of any comet as it passes through a strong gravitational field and the failure of any comet to produce a noticeable perturbation in the motion of any other body it passes near are two pieces of evidence which indicate that the mass of a comet is small.

D. What do we know about the chemical composition of the parts of a comet?

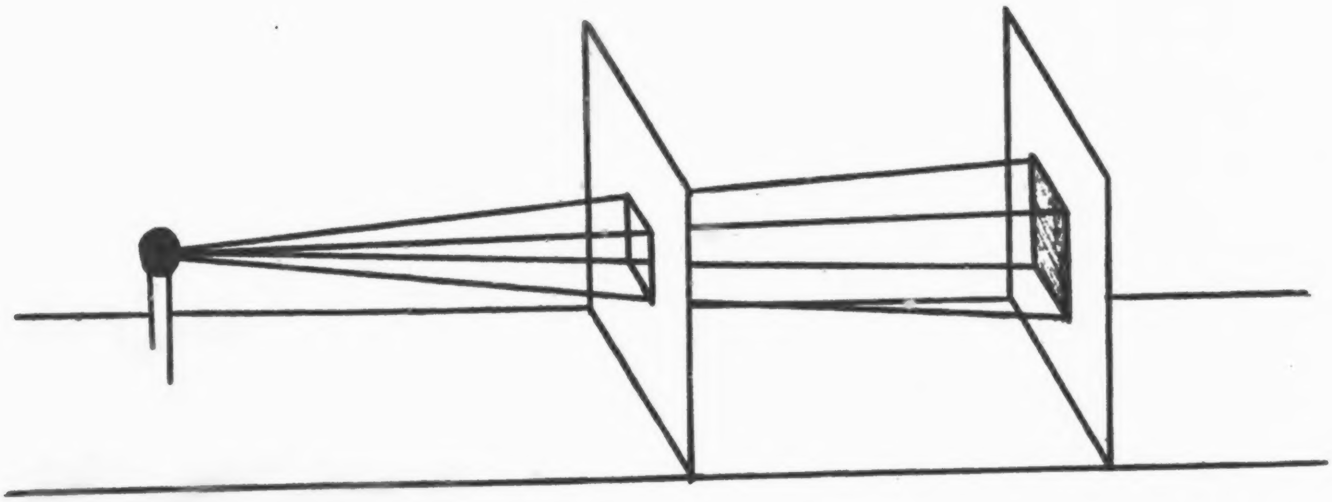
We know the nucleus is solid since its light obeys the inverse square law, indicative of light reflected from a solid. The light from comets appears to have the same spectrum as that from our Sun.

Scientists have analyzed the spectra of the light from comet heads. The analysis indicates that most contain free radicals formed from methane, ammonia, carbon dioxide and water. These radicals are probably generated by solar radiation and distributed around the nucleus by diffusion and light pressure. Analysis of the spectra of the light from the comet tails indicates the presence of ionized carbon monoxide and nitrogen gas.

From these observations, we might envision the comet as a "dirty snowball" which is partially vaporized by solar radiation.

Experiment

Illustrate the inverse square law by setting up a light source so that it shines through square hole onto a poster board. Move the poster board back and forth and measure the area at different distances.



E. What is the source of a comet's light?

Most of a comet's light is sunlight reflected from solids in the nucleus and dust in the head. The remaining light is caused by a fluorescence of ionized molecules.

F. How can we identify different comets?

Each comet has its own particular orbit, usually large, highly elliptical, and randomly oriented with respect to our orbital plane, which it follows over a long period of time.

G. Where did comets have their origin?

The statistical treatment of probabilities for long-period comets predicts the existence of 100 billion comets forming a "comet cloud" about our Sun. This could might extend out from the Sun to a distance of 150,000 astronomical units. Stellar perturbation may cause an occasional comet in the cloud to be "injected" into the interior of the solar system.

H. When will the next bright comet appear?

Halley's comet will reappear in 1986. However, an unknown comet could enter our sky at any time.

11.3 Meteors and Meteorites

Meteors, or "shooting stars" as most people call them, are solid objects, larger than molecules but smaller than asteroids. They are pieces of stony or metallic rock, usually the size of sand particles but sometimes as large as boulders. An average meteor weighs 0.005 ounces, while the largest are estimated to weigh about a ton. Some meteors travel alone while others travel in swarms about the Sun. Meteors travel at speeds as high as 26 miles per second. Sometimes they collide head-on with the Earth and plunge into the Earth's surface. Meteors that reach the Earth are called meteorites. It is estimated that nearly 100 million meteors enter the Earth's atmosphere every day. Most of these are tiny, and they burn up or vaporize in the atmosphere. The steady "rain" onto the Earth of the dust and gas from these meteors adds at least a few tons a day to the mass of the Earth and its atmosphere.

On any clear moonless night an observer may see an occasional "shooting star" moving swiftly through the Earth's atmosphere. The luminosity of meteors is explained by their high velocity. When these small high-speed particles strike our atmosphere, great friction and air pressure result. The friction and compression quickly bring the outer surfaces to white heat, and thus the meteor becomes luminous.

CHAPTER XII

What are the characteristics and statistics of the multitude of stars?

Objectives

1. Why do stars vary in their brightness?
2. How can I measure the distance to a planet or a star?
3. Why do stars have different colors?
4. What are some of the different types of stars in the sky?
5. Is it possible for me to make physical measurements such as density, diameter, and velocity for stars I cannot touch?

Primitive man could not grasp the idea that stars were distant objects independent of the Earth. In their ignorance and superstition they associated the stars with gods and demons who were supposedly revealed by the arrangement and passage of the stars.

As adherence to superstition was gradually replaced by scientific observation, the study of the sky became the ancient science of astronomy. Practitioners of the science recognized that stars and their companions were distant, but real objects in space.

The present patterns of stars are still delineated in the constellations identified by the ancients, even retaining their time-worn names. Today, however, star patterns are also marked off by definite boundaries. Visible stars are determined by their positions in constellations and by their degree of brightness as compared to the brightness of the other stars of the constellation. Since stars differ in their degrees of brightness, the apparent brightness of a star is designated by a number. The two factors determining the apparent brightness of stars are the distance between the Earth and the star and the intensity of light actually produced by the star. The brightest star in a constellation is called alpha and the next, in descending order beta, then gamma and so on through the Greek alphabet for the visible stars.

12.1 Size

Our Sun having a diameter of about 846,000 miles is considered an average-sized star by astronomers. The smallest stars are about 8,000 miles in diameter, whereas Epsilon Auregae, the star known, with a diameter of about two billion miles is more than 2,000 times the diameter of our Sun.

12.2 Mass

The variation of stars with respect to mass is far less than the variation with respect to either density or diameter. Most stars have a mass comparable to that of the Sun. The range of the ordinary stars goes from one-tenth to ten times the mass of the Sun.

12.3 Density

Stars differ far more in density than they do in size. At one extreme there is Betelgeuse the red supergiant star with a density about one ten-millionth that of our Sun or roughly equivalent to our highest vacuums. At the other extreme the companion of Sirius the "White Dwarf" is so dense that one teaspoonful of its matter might weigh a ton. Most stars, however, lie in a range well within the two represented by Betelgeuse and the companion star of Sirius.

12.4 Types of Stars

The Type I Population; the Main Sequence

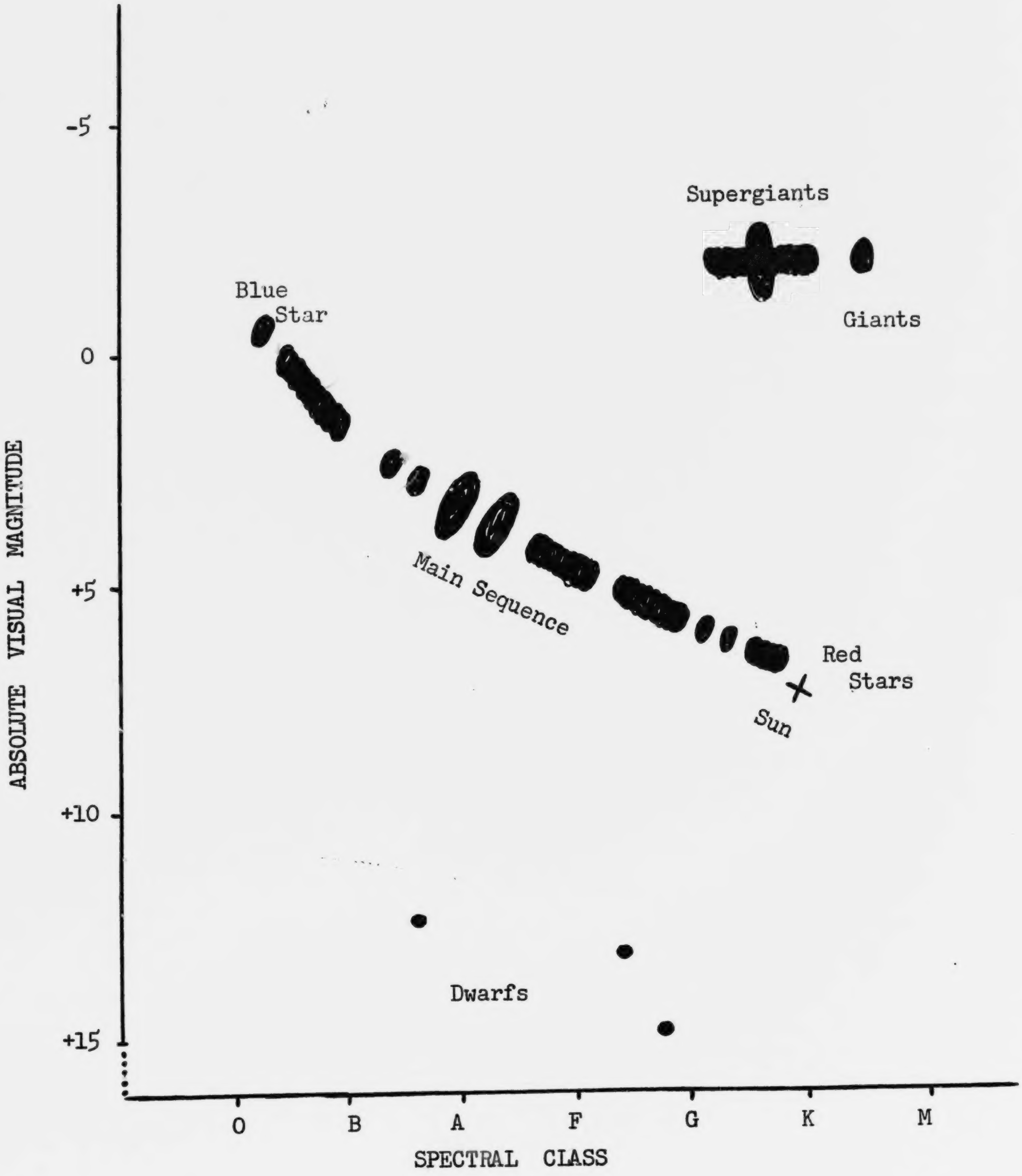
When the absolute magnitudes of stars in our neighborhood are plotted with respect to their spectral classes, the majority of the points appear in a band running diagonally across the diagram. This band is known as the Main Sequence and those stars fainter than absolute magnitude + 10 are often called dwarf stars.

The Sun belongs to the Main Sequence. Blue stars of the sequence are more luminous than the Sun because they are hotter and somewhat larger. Red stars of the sequence are less luminous than the Sun because they are cooler and somewhat smaller.

A. Giant and Dwarf Stars

Giant stars are more luminous than are Main Sequence stars of the same spectral class because they are giants in size as well. All stars of the same class have the same order of surface, temperature, and therefore of surface brightness per square mile. If one class M star, greatly surpasses another in luminosity, its surface must contain many more square miles, which means its diameter must be greater.

Supergiants are the most luminous stars. The red supergiant Betelgeuse is one of these; its diameter is several hundred times that of the Sun. White dwarfs appear extremely faint, despite the fact that their surfaces are bluer and hotter than the Sun's. Some white dwarf stars are smaller than the larger planets. One example of this is the companion of Sirius.


ABSOLUTE VISUAL MAGNITUDE
-5
0
+5
+10
+15
Supergiants
Giants
Blue Star
Main Sequence
Red Stars
Sun
Dwarfs
O
B
A
F
G
K
M
SPECTRAL CLASS

9 neg

B. Double and Variable Stars

1. Binary stars

A binary star is a physically associated pair of stars. In some pairs the stars are far enough apart to be visibly separate when viewed through the telescope, whereas the separate existence of others can be detected only through spectroscopic analysis. Binaries in very close proximity mutually eclipse as they revolve, thereby causing variation in brightness.

2. Visual Binary stars

A binary star appears as a single star to the unaided eye, but is resolved into a physically connected pair when viewed through the telescope. More than 20,000 visual binaries are recognized at this time.

3. Spectroscopic Binary stars

These stars are mutually revolving pairs which are not resolved into separate entities by use of the telescope. They are recognized by the periodic oscillations of the lines in their spectra. These oscillations produce the Doppler Effect, as the two stars alternately approach and recede from us in their revolutions. Capella and Spica are examples among the brightest spectroscopic binary stars.

4. Eclipsing Binary Stars

These stars have their orbits so nearly edgewise to the Earth that the stars mutually eclipse twice in the course of each revolution. Through the telescope they appear as single stars which become fainter while the eclipses are in progress. Within the periods in which they revolve, the time involved in emitted light fluctuation averages between 2 to 3 days for most eclipsing binaries. Yet for many, the eclipse, and hence the fluctuating light, lasts only a few hours. Algol, the "Demon Star" is among the most famous of the eclipsing stars.

5. Variable Stars

Some stars vary in brightness. The fluctuations in their light are discovered and studied by comparing them repeatedly with stars of constant brightness. The comparisons are often made in photographs taken at different times, or with a photoelectric cell where the highest precision is required.

a. Intrinsic Variable Stars

The variation in brightness of stars has many causes other than natural eclipses. Some of these causes will be described in the information on pulsating stars, irregular variable stars, and explosive stars.

(1) Pulsating Stars

Many intrinsic variable stars fluctuate in brightness because they are rhythmically contracting and expanding. They become hotter as they contract and cooler as they expand. They are brightest to us not when they are most compressed but when their gases are moving outward fastest, and are faintest when their gases are returning fastest. Pulsating stars are mainly of 4 types: R R Lyrae variables, cephid variables, long-period variables, and other semi-regular variables.

R R Lyrae variables, which are blue giants of Class A, are named after one of their brightest examples. They are also known as cluster variables because they were first observed in the globular star clusters. All R R Lyrae variable stars have zero absolute median magnitude which is the average of their greatest and least brightness.

Cephid variable stars take their name from one of their earliest recognized examples, Delta Cephei. Delta Cephei is located in the triangle that marks the southeast corner of the spire-like Cephus in the northern sky. The cepheids have the lines in their spectra displaced farthest to the violet, showing that the gases in front of the stars are moving toward us at greatest speed. Cepheid stars are yellow supergiants of classes F and G. Their periods of variable brightness range from a day to several weeks, but are frequently found to require five days for completing a brightness cycle.

(2) Long-Period Variable Stars

Many red supergiant and giant stars, mainly of Class M, are variable in brightness in a semi-regular manner. Their periods range from a few months to more than 2 years, with an average time requirement of 275 days. Their light variations range from 4 to nearly 10 visual magnitudes.

(3) Irregular Variable Stars

Red supergiant and giant stars frequently vary irregularly within rather narrow limits, seldom more than half a magnitude, because of effects in their atmospheres. Betelgeuse, having a visual range from magnitude 0.2 to 1.2 is the brightest of these irregular variables.

(4) Flare Stars

Some red main sequence stars are known as flare stars. They are subject to intense outbursts of very short duration remindful of the solar flares.

(5) Explosive Stars

These stars, which are small and dense, flare suddenly from faint obscurity into bright prominence for a few months, and then again fade. An explosive star is also known as a Nova (new) or supernova according to its brightness, which may reach a magnitude of +1 or even brighter. The brightest Nova ever known to have been witnessed by man, appeared as bright as Venus.

b. Constellations

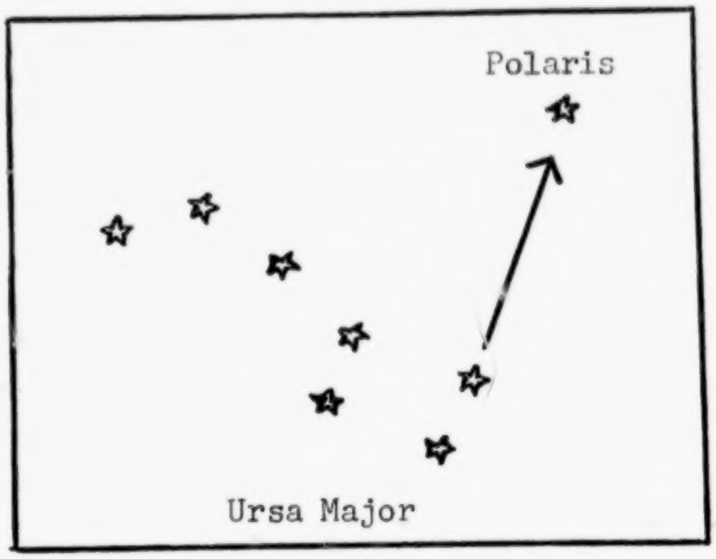
Constellations are star patterns which divide the sky into regions.

There are 90 constellations which have been given names to commemorate people in their myths and legends. Many of these names, Leo, (lion), Ursa Major (great bear), Taurus (bull), Draco (dragon), Scorpio (scorpio (scorpio), and Orion (hunter), are still used today.

Because of the rotation of the Earth on its axis, all constellations appear to rotate about Polaris, the pole star. Polaris appears almost exactly over the north pole of the Earth, because the Earth's axis is directed almost straight at Polaris.

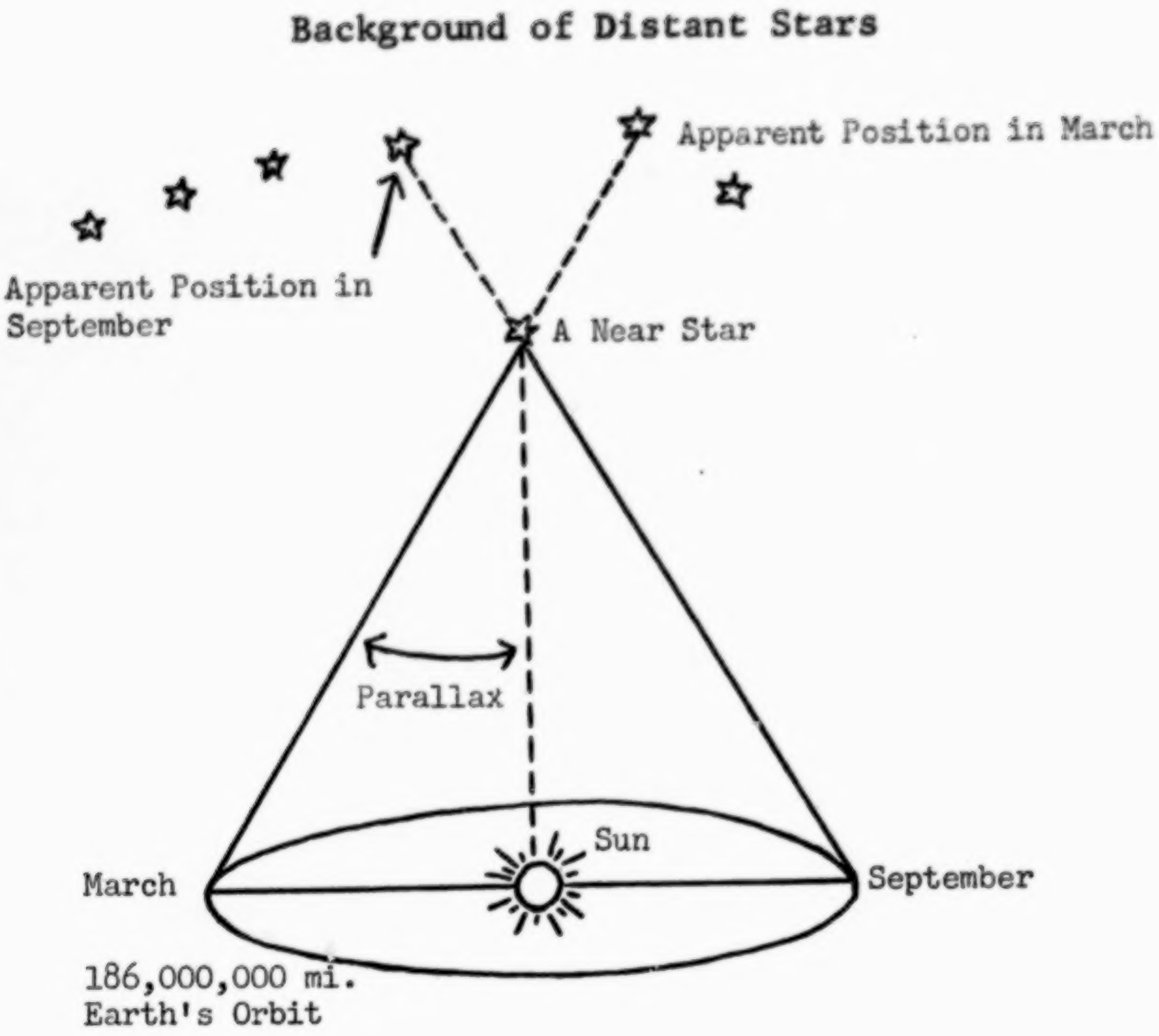
As the Earth speeds around the Sun, and rotates on its axis, different regions of the heavens are seen. Some constellations are visible at one season and not at another. Orion is easily visible in the winter sky but not during the short summer nights. Hercules can be seen during the summer but not during the winter.

The best-known constellation is Ursa Major, the Great Bear, often called the Big Dipper because the seven brightest stars are arranged in the shape of a dipper. The two stars forming the far side of the Dipper are called the pointers, because an imaginary line segment projects through them and across the sky intersecting Polaris.



12.5 How is the distance to a star calculated?

The distance to the approximately 6000 near stars may be computed by trigonometric methods. The diameter of the Earth's orbit is used as the base line from which the astronomer sights a star two times, six months apart. The lines of sight from the opposite ends of the Earth's orbit compose the two sides of the triangle. Knowing the length of the base, and the two angles he can compute the distance to the star.


Background of Distant Stars
Apparent Position in March
Apparent Position in September
A Near Star
Parallax
Sun
March
September
186,000,000 mi.
Earth's Orbit

Astronomers have taken the average distance from the Earth to the Sun, or approximately 92,000,000 miles as a unit of measure called the astronomical unit. The next nearest stars are about 270,000 times as far as our Sun. These are Alpha Centauri, the second brightest star in the southern hemisphere, and Proxima Centauri, of the constellation Centaur. They are about 25,000,000,000,000 (25 trillion) miles from the Earth.

The most commonly used unit of distance in astronomy is the light year, the distance a ray of light would travel in one year. Light travels at approximately 186,000 miles per second, so one light year would be $186{,}000\ \frac{\text{miles}}{\text{second}}$ X $60\ \frac{\text{seconds}}{\text{minutes}}$ X $60\ \frac{\text{minutes}}{\text{hour}}$ X $24\ \frac{\text{hours}}{\text{day}}$ X $365\ \frac{\text{days}}{\text{year}}$. This is almost 6,000,000,000,000 (6 trillion) miles per year.

Another unit of distance is the Parsec. This is determined by measuring the star's shift in position as seen from the Earth in terms of an angle called the Parallax of the star. The larger the Parallax, the nearer the star.

A Parsec is the distance at which a star would have a Parallax of one second of arc (one degree equals 60 minutes, one minute equals 60 seconds); so one second equals 1/3,600 of a degree. No star is close enough to have a Parallax of one second. The word Parsec comes from Parallax of one second, and a Parsec is equal to 3.26 light-years.

Distances to some Stars

Name of star	Distances in light years
Alpha Centauri	4.3
Vega	27.0
Procyon	11.0
Sirius	8.8
Polaris	300.0
Sun	8 light minutes
Deneb	1500.0

12.6 Star Brightness

Why does our Sun look so much larger and brighter than the other stars? A star's apparent brightness depends on its size and surface temperature, as well as its distance; but the true brightness depends only on its size and surface temperature. Because it is so close to us, our Sun seems larger than the other stars, even though it is only of medium size, and temperature when compared with all other stars.

Long before telescopes were invented, astronomers have identified stars of twenty-fourth magnitude. The system of classification is easily understood, if one knows that a change from one magnitude to the next highest magnitude is equivalent to appearing to be 2.5 times as bright. In other words, a first magnitude star is 2.5 times as bright as a second magnitude star, and a second magnitude star is 2.5 times as bright as a third, etc. By this method, first magnitude stars are about 100 times $(2.5)^5$ bright as those of the sixth magnitude. (Why is the exponent 5 rather than 6?) To provide for small differences, decimal fractions are added. Since the apparent magnitude of a star is limited to a measure of how bright it looks from the Earth, astronomers need a method to compare the luminosity of stars as it would be, if viewed from the same distance. If we know the apparent brightness of a star, and its distance, it is easy to calculate how bright it would appear at any given distance. To perform this operation, an astronomer defines a star's absolute magnitude as the apparent magnitude it would have at a distance of 32.6 light years (10 Parsecs). A few stars are so bright, their magnitudes must be expressed as a negative number. The rule to remember is, "The lower the number, the brighter the star."

Some of the Brightest Stars

Name	Apparent Magnitude	Absolute Magnitude
Sun	-26.8*	4.8
Sirius	1.4	1.5
Rigel	.1	-6.5*
Antares	1.0	-4.0*
Deneb	1.2	-7.0*

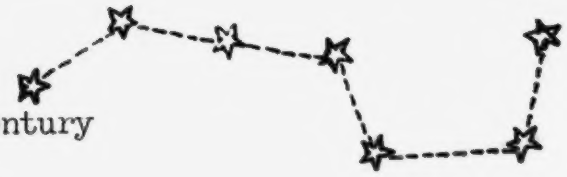
* Minus magnitudes are used in astronomy to relate relative brightness greater than the original scale. From the table we then conclude that the absolute magnitude of Deneb is almost twice as great as the magnitude of Antares.

12.7 Motion

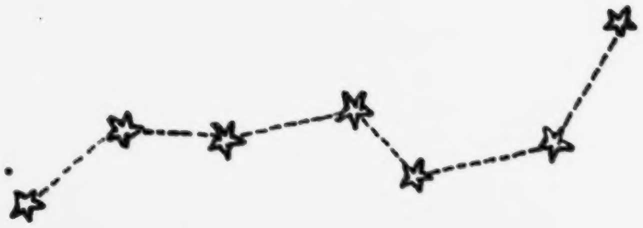
All the stars in our galaxy rotate at very high speeds which differ with each star's distance from the galaxy's center.

Example: Sun-speed is about 135 miles a second. The motion of a star may be detected by the astronomer in either proper motion or radial velocity. Proper motion may be defined as the rate at which the star changes its position among the other stars in the sky. This motion may be seen by comparing two photographs--one taken long after the other--which will indicate the star's displacement against its background of more distant stars.

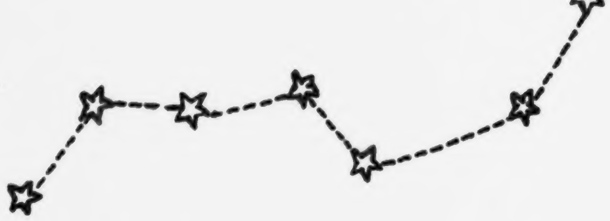
It is difficult to observe proper motion of our fainter stars (those which are far away from us) over a short period of time. However, one of these stars will show movement from its original position in a span of 50,000 years or more. It is easy to detect the proper motion of stars which are close to us. The Barnard Star moved an eighth of the apparent width of the full moon in a period of 22 years. This movement was recorded by two separate photographs, the first taken on August 23, 1894 and the second on May 30, 1916 at Yerkes Observatory. This star was named for the astronomer who first observed its rapid movement. This is a star of the tenth magnitude in Ophiuchus where it moves at a rate of 10.3 seconds a year. This rate is sufficient to cause it to move the width of the moon in 175 years. The chart on the next page shows changes in the Big Dipper due to motion of individual stars.



Big Dipper in the Twentieth Century



Big Dipper in 35,000 A. D.



Big Dipper in 55,000 A. D.

The rate at which a star is moving either toward or away from us s termed radial velocity. It can be discerned from a shift of the star's spectral lines. If a spectral line moves toward the red this is an indication that the star is receding. If a spectral line moves toward the violet this is an indication that the star is approaching us. Some stars have radial velocities of 60 miles a second, however, most have velocities of 20 to 30 miles a second.

Spectral line differentiation may be explained by an analogy to the Doppler Effect. When the source is approaching the observer, the waves are crowded together, so that the wave lengths are diminished and the lines will appear displaced toward the violet end of the spectrum. Where the source is receding, the waves are spread farther apart, so that their lengths are increased, and the lines will be displaced toward the red end of the spectrum.

12.8 Color and Temperature

All colors of light are emitted by the stars. Hotter stars will emit more light at the blue end of the spectrum and the cooler ones emit more light at the red end of the spectrum. Thusly, the cooler a star is, the redder it appears. Antares and Betelgeuse are examples of red stars. Capella and our Sun are examples of yellow stars, whereas Vega, Rigel, and Sirius, being very hot, are examples of blue stars.

Temperature change in stars may be explained by using an iron bar which has been subjected to intense heat. As the temperature is increased the color changes from red to orange and finally at its hottest point it becomes white.

Astronomers classify stars into the following seven classes on the basis of their spectral lines.

Class	Surface Temperature	Color	Example
O	over 25,000° C.	Blue	Iota Orionis
B	15,000 - 30,000° C.	Blue-white	Rigel, Spica
A	8,000 - 11,000° C.	White	Sirius, Vega
F	about 7,500° C.	White-yellow	Canopus, Procyon
G	about 6,000° C.	Yellow	Sun, Capella
K	about 4,000° C.	Orange	Arcturus, Aldebaran
M	about 3,000° C.	Red	Antares, Betelgeuse

CHAPTER XIII

What valuable information have I gained through my study of the stars?

Objectives

1. Are the galaxies of our universe similar in structure?
2. What can we find in interstellar space that we are unable to create on Earth?
3. What kinds of compounds do we think make up interstellar dust?
4. If you were going to visit a star to secure heavy metals, which type would you choose?

13.1 Galaxies and Their Shapes

Sky watchers of early times noticed, that in addition to the many thousands of sharp points of light that they called stars, there were a few hazy, blurred patches in the sky to which they gave the name nebulae, which means cloud. Modern telescopes have shown that many of these nebulae are really systems or families containing millions of stars. Today we call these systems galaxies.

The galaxy to which our planet belongs is called the Milky Way. In this galaxy our Sun is one star among billions. Every star that we can see with the naked eye is part of our Milky Way.

Galaxies appear to be of three main types: Spiral, Elliptical, and Irregular.

A. Spiral

The Milky Way is a spiral galaxy. It rotates like a big whirlpool, in which thousands of stars move around a central point in a manner similar to the planets' rotation around our Sun. Stars near the center rotate faster than those farther out. Spiral galaxies have a central lens-shaped nucleus of stars surrounded by a flat disk of stars. This flat disk usually consits of two arms emerging from the center portion. These arms contain stars, dust, and gas. The nucleus is free of dust and gas. The appearance of a spiral galaxy depends on its position with respect to the viewer. About 75 per cent of presently known galaxies are spirals. (For photographs of spiral galaxies see The Astronomical Universe, Wasley S. Krogdahl, The MacMillan Co., p. 466-467.)

B. Elliptical

Elliptical galaxies appear through the telescope as spherical or flattened systems that show neither spiral arms nor clouds of gas and dust. Since this interstellar material is absent it should indicate that stars are no longer being "born" in these galaxies. In this respect the elliptical galaxies resemble the nuclei of the spiral type galaxies. About 21 per cent of known galaxies are of this type. (For photographs of elliptical galaxy see The Astronomical Universe, Wasley S. Krogdahl, The MacMillan Co., p. 469.)

C. Irregular

The least numerous type of galaxies are the class of irregular. Irregulars exhibit no symmetery of form or plan. They represent only a small portion of known galaxies. The two Magellanic clouds that are "satellites" of our galaxy resemble irregular galaxies. (For photograph of an irregular galaxy see The Astronomical Universe, Wasley S. Krogdahl, The MacMillan Co., p.479.

13.2 Space Between Stars

Scattered thoughout the sky are clusters of stars, which appear faint to the naked eye, but clear and beautiful through a telescope. In other regions hazy spots can be seen which are in reality great luminous clouds of gas. Dark areas are found scattered in the sky which were first thought to be regions devoid of stars, but modern research findings have proved they are tremendous clouds of gas and dust which block off the light from everything beyond them.

A. Cosmic Dust and Gas

Clouds of gas and dust exist in the interstellar space between stars. These clouds with their diverse densities, are found everywhere, but the densities are always so low that even the highest vacuum produced on Earth is dense in comparison. Nevertheless, the total quantity of material contained in their enormous volumes is as large as that found in the stars. The gas of the clouds is believed to be largely hydrogen. The composition of the tiny dust grains, each about four-millionths of an inch long, is not known, but hydrogen compounds are believed to comprise much of it. These dust grains are so far apart, on the average, that only one would be found in a space 100 feet long, 100 feet wide, and 40 feet high.

Astronomers have found a relationship between the type of star found in a galaxy and the presence or absence of instellar clouds of dust and gas. In the elliptical galaxies, and in the nuclei or centers of spiral galaxies, where no dust and gas are present, the brightest stars are red, and the stars are poor in heavy elements. In the arms of the spiral galaxies, where great clouds of dust and gas are present, the brightest stars are much hotter blue-white giants, and the stars are somewhat richer in heavy elements.

CHAPTER XIV

ESCAPE FROM EARTH'S GRAVITY

UNIT V. What are some of the questions and problems that man must anticipate and answer before he can successfully engage in space flight?

Objectives

1. When given the responsibility for piloting a spaceship in a circular orbit, what critical speed and direction must I establish?
2. If I can get as far from the Earth as the moon, what speed must I maintain in my spacecraft to avoid being pulled back to Earth?
3. What contribution has Newton made to our space program?
4. If someone tells you that all you have to do to escape from the Earth is to reach a velocity of 7.0 miles per second, will you believe it?
5. Do you think the Earth's gravitational attraction accelerates a bullet or the moon more?
6. If a person were requested to reduce his weight from 200 pounds to 184 pounds without exercising or dieting, what planet would you have him visit?
7. How high do you think you could jump on Mars?

14.1 What principles are involved in man's newly found ability to "defy" the law of gravity which supposedly forces objects thrown from the Earth's surface to return to it?

Before 1957 there were at least 32 naturally occurring satellites revolving around the planets in our solar system. The following chart lists each planet and the number of "moons" or satellites.

Planet	Number of Satellites
Mercury	0
Venus	0
Earth	1
Mars	2
Jupiter	12
Saturn	10
Uranus	5
Neptune	2
Pluto	0

On October 4, 1957, the Soviet Union launched the first artificial satellite, Sputnik I. Since that time a large number of satellites have been launched by the United States and the Soviet Union, but their orbits in general are very similar and there is no point in listing them. It is more important to consider the general principles involved in launching any satellite into an orbit around the Earth.

Let us begin by briefly summarizing Newton's Laws of Motion. Newton was a young man only slightly over 20 years of age when he, in one bold stroke, not only added to the ideas of his predecessors, but integrated all of these ideas into a single system of mechanics. The basic foundation of his system is three simple principles, now known as Newton's Laws of Motion.

A. Newton's Laws of Motion

Law 1: Every body remains in its state of rest or of uniform motion in a straight line unless it is compelled to change that state by unbalanced forces impressed upon it.

This law has three distinct parts. First, a body at rest tends to remain at rest. We realize this is true from our many everyday experiences. A body does not start moving without a cause. If we suddenly see a ball, originally at rest, start moving across the floor we know that there is a "cause " for this motion.

Secondly, the natural tendency of a body in motion is to move in a straight line. If we roll a ball across a level floor, we expect the ball to go straight, and if it does not, we know there is some deterring force operating. Again our experiences have convinced us that it is the nature of material objects to move in a straight line.

The third part of Newton's first law (that a body continues to move with constant speed unless acted upon by an unbalanced force) seems to contradict our experiences.

Because we are unaware of many forces such as friction, weight components and gravitational attraction, our experiences seem to indicate that a body will move for awhile but will finally slow down and stop.

Law 2: When an unbalanced force acts on a body, the body will accelerate. The acceleration is in direction of and proportional to the unbalanced force.

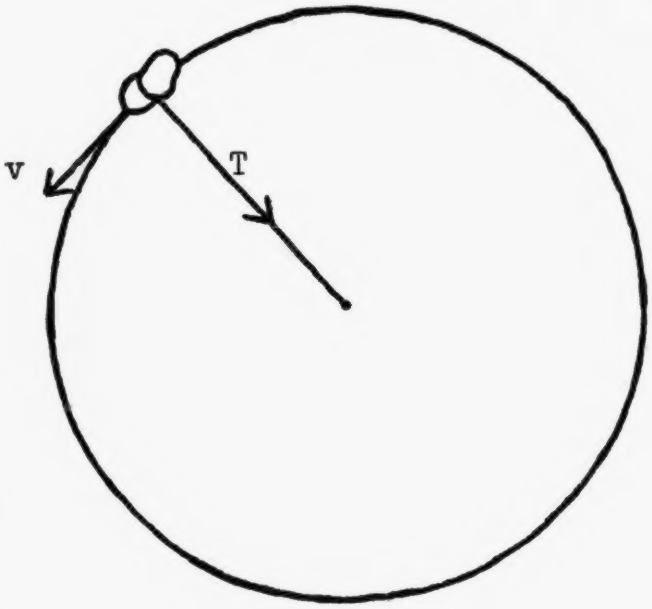
Whereas Newton's first law tells us what to expect from a body when it meets no interference, his second law tells what happens when a body is met with interference. It will speed up, slow down, or be deflected from its straight-line path. In other words, it will suffer a change in velocity, where velocity has been defined to include magnitude (speed) and direction. Thus a change in velocity means a change in speed, and/or direction.

Law 3: For every action there is an equal and opposite reaction.

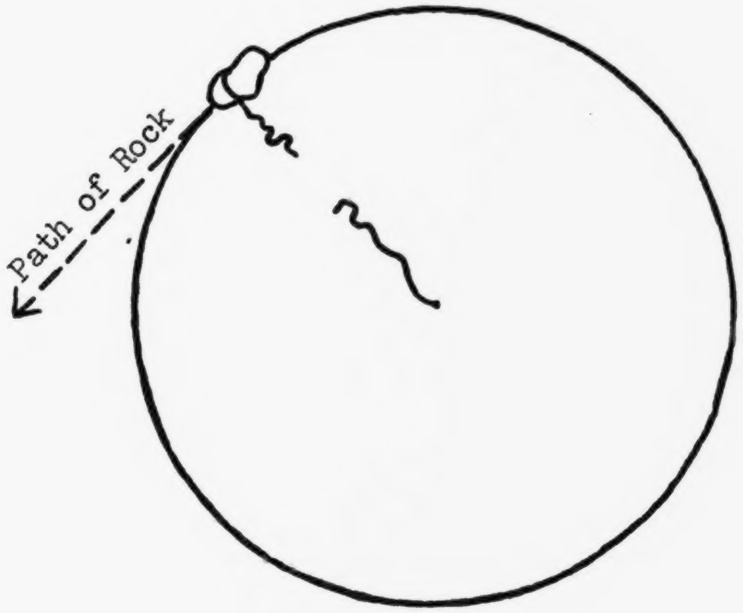
Even though this statement is quite obviously true in most cases, it can be misleading if one is not careful. If you push on a wall with a force of 30 pounds, then the wall pushes back on you with a force of 30 pounds. Notice that both forces are not on the same body, but are directed to contrary parts. The wall pushing on you is the reaction to your force on the wall. Consider a book placed on a table. The book presses downward on the table with a force equal to its weight and the table pushes back on the book with an equal force. This is action and reaction. If we consider the book alone, it has two forces acting on it--the gravitational force (weight) acting vertically downward and the table pushing vertically upward. These forces are equal in magnitude and opposite in direction, but they are not action and reaction since they both act on the book.

B. Centripetal Force and Acceleration

In the 17th century it was generally believed that some force or power was required to keep the planets in their orbit around the Sun. However, Galileo argued that once started, the planets would remain in motion in a straight line unless some force caused the planets to move in a nearly circular path. In other words, for a body to move in a circular path it must continually have an acceleration toward the center. This acceleration is called the centripetal acceleration and the central force that produces the acceleration is called the centripetal force. Consider, for a moment, a stone being whirled about at the end of a string. The tension in the string pulls the stone into its circular paht. Thus the tension in the string is the required centripetal force.



The centripetal force is supplied by the tension in the string.



If string breaks, the rock moves in a straight line tangent to the circle.

The stone can be thought of as exerting an equal force on the string directly away from the center. This force is called the centrifugal (center-fleeing) force. If the string were to break, the stone would move in a straight line tangent to its circular path. Although it is often stated that the centrifugal force pulls the stone away, it is more correct to say that the stone flies off at a tangent because the centripetal force fails to keep it in a circular path.

C. Newton's Law of Universal Gravitation

Newton wondered whether the central force which kept a planet in its orbit might be an attraction between the planet and the Sun. It was obvious to him that the Earth exerted a force of attraction upon all objects near its surface. Such a force is a mutual force, which acts on the object as well as the Earth. As an example of this, consider that a falling apple and the Earth are pulling on each other. Newton reasoned that this force of attraction extended as far as the moon and produced the centripetal acceleration required to keep the moon in its orbit. Newton's logical reasong surmised that the attractive force between the Sun and each of the planets could provide the centripetal acceleration necessary to keep each in its respective orbit. Thus Newton hypothesized the existence of a universal attraction between all bodies everywhere in space. Finally he quantified his theory and concluded that the universal attraction is directly proportional to the product of the masses and inversely proportional to the square of the distance between them.

D. Weight--How does weight depend upon gravity?

The difference between mass and weight depends upon gravity. A body's mass is the amount of matter in it, while its weight is the pull of gravity upon this mass. In other words, the weight of a body on the surface of the Earth is the gravitational attraction between the mass of the body and the mass of the Earth as explained by Newton's Universal Gravitational Attraction. Thus a gravitational force is related to the mass of an object. If a body is massive, it will have a large gravitational force. If it is not massive, it will have negligible gravitation.

This table shows how the force of gravity varies relative to gravity on the Earth.

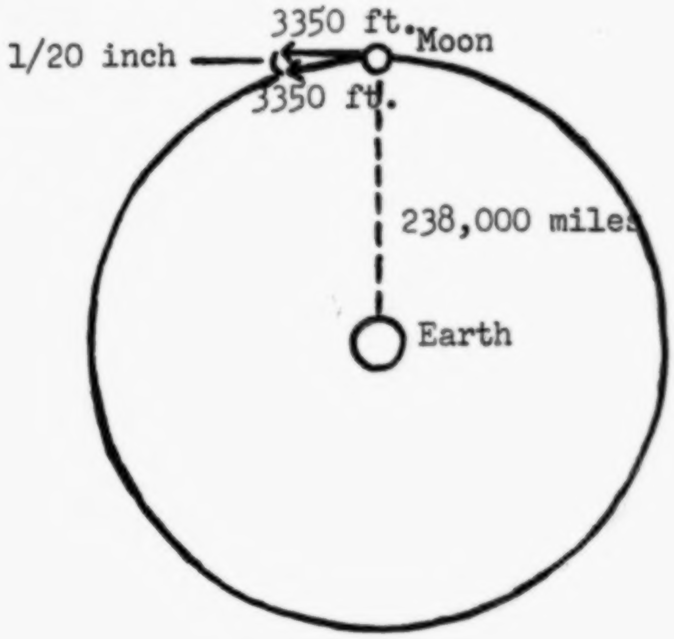
Location	Gravity (Earth = 1)
Sun	28.00
Moon	0.17
Mercury	0.26
Venus	0.92
Earth	1.00
Mars	0.38
Jupiter	2.64
Saturn	1.15
Uranus	0.96
Neptune	1.00
Pluto	?

From this table it is easy to see that a man weighing 150 pounds on Earth would weigh 4200 pounds on the Sun and only 25.5 pounds on the moon. But in each case his mass would remain the same.

D. Orbital Motion

Suppose an apple is dropped from some height toward the surface of the Earth. It will have an acceleration of 32 ft./sec. This acceleration is inversely proportional to the square of the distance from the center of the Earth. The apple's distance from the Earth's center is about 4000 miles, and the moon's distance is 239,000 miles--about 60 times farther. Thus the moon's acceleration is $\frac{1}{60^2}$ or $\frac{1}{3600}$ as much as the apple.

In one second the apple has accelerated to a speed of 32 ft./sec. Its average speed during the first second then is 16 ft./sec., since it started from rest, and the distance traveled is 16 feet. The moon drops toward the Earth only about 16/3600 feet or 1/20 inch in one second since its acceleration is only $\frac{1}{3600}$ of the apple's acceleration. In other words in one second the moon will move forward 3350 feet in its orbit and fall 1/20 inch toward the Earth. (See the diagram below)



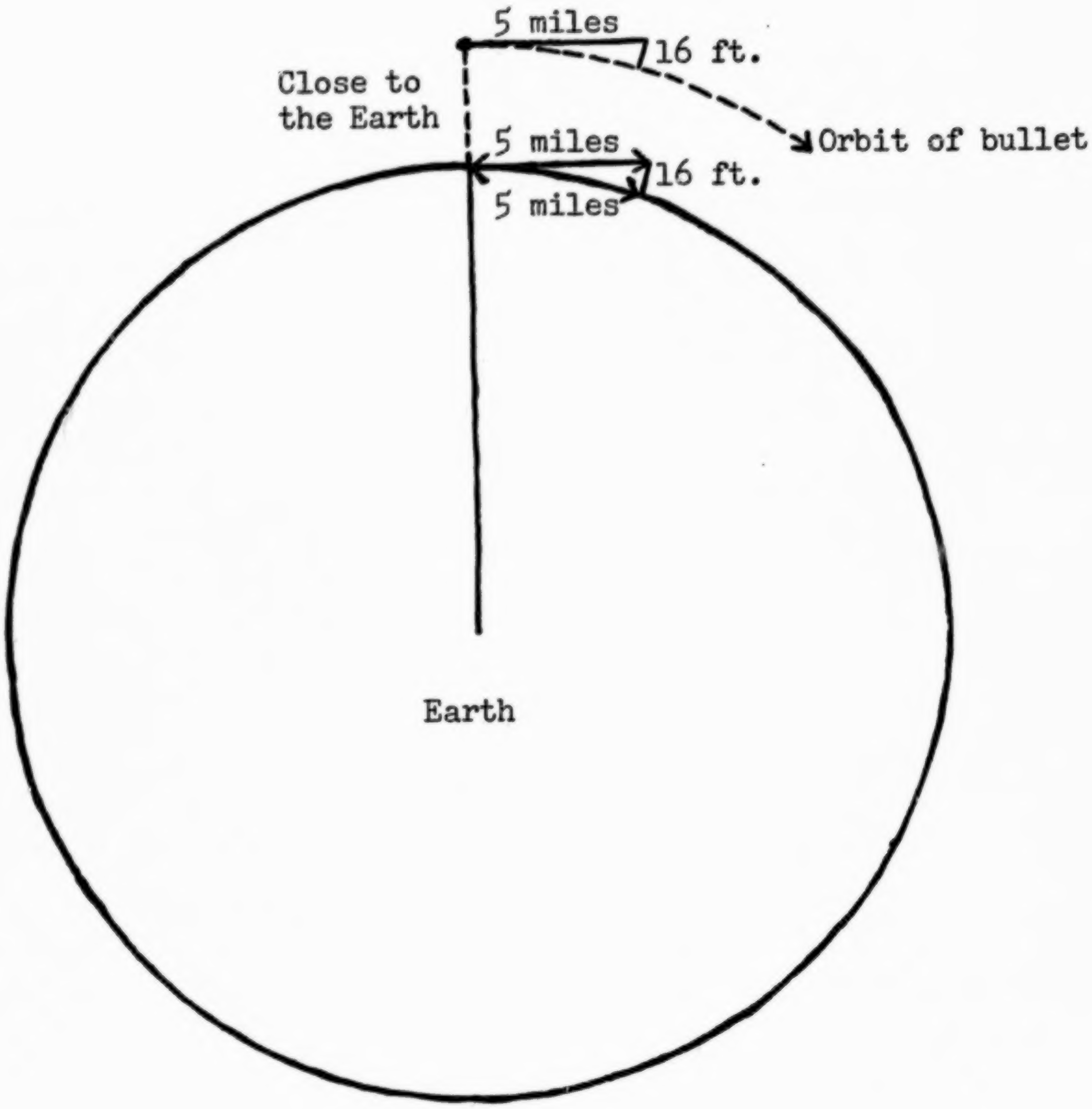
The Moon is "falling" Toward the Earth

As the moon moves forward in its orbit it falls toward the Earth instead of moving in the straight line A B. This is due to the gravitational attraction between the moon and the Earth. However, due to the curvature of the Earth, the moon is still the same distance away from the Earth. At the end of 27 1/3 days the moon has "fallen" through one complete revolution of the Earth and is back to its starting point.

The orbital motion of the planets are also easily understood in terms of Newton's law of gravitation and laws of motion. At any instant of time, the orbital speed of a planet would tend to carry it off into space in a straight line tangent to its orbit. The gravitational attraction betwen the planet and the Sun provides the proper centripetal force to cause the planet to accelerate into its circular path. Consequently the planets falls around the Sun in a nearly circular path.

Let us state emphatically that orbital motion is not the balance between two forces, the force of gravitation pulling the planet toward the Sun and an outward centrifugal force that keeps the planet from falling into the Sun. This explanation is frequently used, but it is entirely incorrect.

The conditions necessary for the orbiting of an artificial satellite are the same as those for any other astronomical body. Very specifically one should say that the satellite must be given an orbital speed and direction such that the gravitational attraction between the satellite and the Earth is just equal to the necessary centripetal force to keep it in a circular orbit. To illustrate how a satellite can be launched, imagine a man in a balloon high above the surface of the Earth. Let us assume that at this height the friction of the air can be neglected entirely. Next, suppose the man fires a rifle exactly parallel to the surface of the Earth. The only force that acts on the bullet is the gravitational attraction of the Earth. If the bullet is given some small muzzle velocity (v_1) it will continue to have this forward velocity, but the gravitational force will accelerate it downward so that it strikes the Earth. If it is given some large muzzle velocity (v_2) it will travel forward a greater distance before it strikes the ground. However, if it is given a velocity of 5 miles/sec., the gravitational force between the bullet and the Earth is just sufficient to produce the centripetal acceleration necessary for a circular orbit around the Earth. The bullet now follows a pattern of motion similar to that of the moon around the Earth. The bullet travels with an orbital speed of 5 miles/sec. and is being pulled toward the Earth by gravity. Therefore during the first second while the bullet is traveling 5 miles, it will fall 16 feet toward the Earth. But the natural curvature of the Earth is such that in 5 miles the Earth's surface curves away from the horizontal by 16 feet. Consequently one second later the bullet is no closer to the surface of the Earth than it was at its point of initial ejection. This same series of events is repeated each second of the bullet's flight.


5 miles
16 ft.
Close to
the Earth
5 miles
Orbit of bullet
16 ft.
5 miles
Earth

A bullet with a muzzle velocity of 5 miles/sec. falls toward the Earth but never reaches it.

We can now understand why five miles a second (18,000 m.p.h.) is the critical speed for injecting a spacecraft into orbit close to the Earth. Farther from the Earth, the speed necessary for an object to stay in orbit is lower, because the gravitational force is smaller. The gravitational force between any two objects is inversely proportional to the square of the distance between them. This means that if the distance between two bodies is doubled, the gravitational force between them becomes one-fourth as great; if the distance is four times greater, the pull of gravity is only a sixteenth as great. Thus the moon, at a distance of 240,000 miles from the Earth, only needs to travel 3/5 of a mile a second to keep from being pulled into the Earth.

Let us assume that a satellite has been injected into a precise circular orbit around the Earth at a speed of 18,000 per hour. In effect, gravity has been exactly offset by the satellite's speed. It seems to be weightless and "floats" in space. However, it is floating at the same exceedingly high speed with which it entered orbit. It needs no additional power to maintain its speed because there is no air resistance to slow it down, whereas an airplane flying in the atmosphere a few miles from the Earth's surface needs constant power to overcome air resistance.

14.2 What factors determine the orbit of a spacecraft?

Before discussing the factors which determine the orbit of a spacecraft, it would be well to define some terms that have a specific meaning when applied to spacecraft and satellite orbits and may or may not have the same meaning when applied elsewhere.

1. "burn-out" - the instant when the thrust supplied by the spacecraft's fuel is shut off.
2. "burn-out speed" - the speed which the spacecraft has at "burn-out."
3. apogee - the point of the satellite orbit that is fartherest from the center of the Earth.
4. perigee - the point of the satellite orbit that is closest to the center of the Earth.
5. escape velocity - the speed an object must reach to overcome the gravitational attraction of a planet, such as the Earth, or the speed a rocket must reach in order to leave the Earth's immediate gravitational field. The escape velocity at the surface of the Earth is 7 miles/sec.
6. "roll" - the term applied to the rotational motion of a spacecraft.
7. "yaw" - the motion of the spacecraft from side to side.
8. "pitch" - is the up-and-down motion of the spacecraft.
9. "circular satellite velocity" - the direction and speed that a satellite must have to move in a circular orbit around the Earth. The speed that a satellite must have at the surface of the Earth is about 5 miles/sec. or 18,000 miles/hour.

A. Speed at "burn-out"

Suppose that a spacecraft is shot up to an altitude of 150 miles and turned so that it is moving parallel to the surface of the Earth, then finally given a forward thrust. The size and the shape of the orbit this spacecraft will take depends on the exact direction and speed at the instant of "burn-out." The relation between the circular satellite velocity and the speed at burn-out gives a good indication of the orbit. If the burn-out speed is equal to the circular satellite velocity then of course the orbit will be a circle about the center of the Earth. If the satellite were launched so that its entire orbit is outside the Earth's atmosphere, then it would remain in orbit indenfinitely.

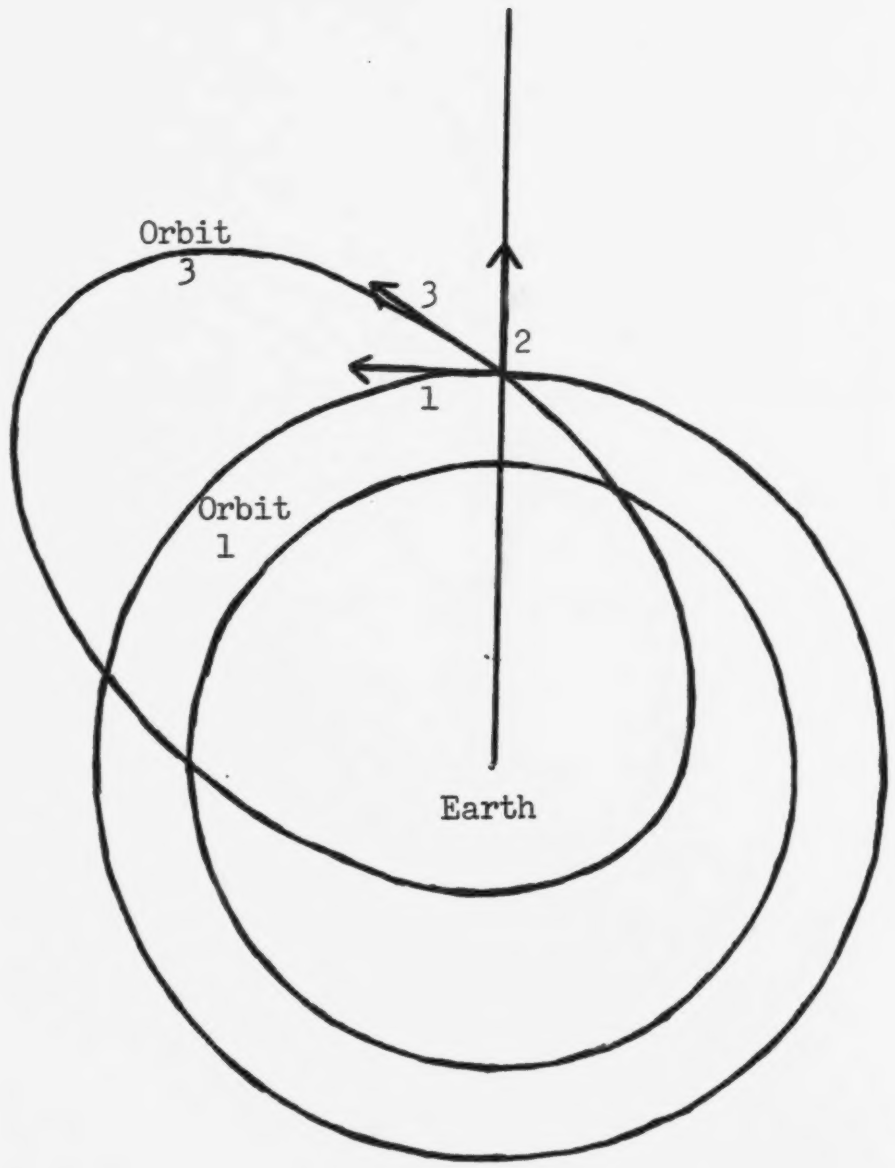
If the burn-out speed is below the circular satellite velocity, the orbit would be an ellipse. The apogee of the orbit would be the point of burn-out, and the center of the Earth would be at one foci of the ellipse. When the burn-out speed is quite small as compared to the circular satellite velocity, most of the elliptical orbit would either be in the dense portion of the Earth's atmosphere or lie beneath the surface of the Earth. In either case the satellite would be doomed to destruction either by burning up in the dense Earth's atmosphere or colliding with the surface of the Earth.

If the burn-out speed is above 7 miles/sec. (the velocity of escape), the satellite will follow a parabolic path and escape from the Earth's gravitational field into space. In each of the above examples the direction of the satellite at burn-out was considered to be parallel to the surface of the Earth.

B. Direction at "burn-out"

The equation of the orbit of the Earth satellite can be developed from purely physical concepts. If this is done, one sees that the size of the orbit (length of the major axis) depends only on the speed at burn-out and not on the direction. The shape of the orbit does, however, depend on the direction of motion of the satellite.

Suppose that three different satellites are launched, each with a burn-out speed of 5 miles per second, but each having a different direction of motion at burn-out. Suppose that the direction of motion of the first is parallel to the surface of the Earth, the second one directed radially outward from the surface of the Earth, and the third at an angle of 45° with respect to the vertical. In each case the length of the major axis would be the same, since all three have the same burn-out speed, but the shape would be different. In the first case, as previously mentioned, the orbit will be a circle with the center at the center of the Earth. In the second case the satellite will move vertically upward until its velocity becomes zero, then fall back to the surface of the earth. In the third case the orbit is too eccentric to clear the surface of the Earth, thus the satellite follows its elliptical path until it collides with the Earth.


Orbit
3
3
2
1
Orbit
1
Earth

Orbits resulting from different directions of motion at "burn-out."

Experiences

Centrifugal force:

Whirl a pail, partly filled with water, around your head. The water, instead of spilling, will be kept in the pail by centrifugal force.

"What is gravity?"

Class discussions - Everyday we are experiencing gravity. Gravity is essential to the full explanation of weather, movements of animals, operation of machines, and a host of other phenomena. Have students relate their concepts of gravity and to clarify some of their concepts through discussion.

To show centripetal force:

For this experience provide plenty of room and a place where nothing can be broken. A ball or sponge swinging in different directions can be released to move toward ceiling, wall, or floor.

Securely fasten one end of a string 3 to 6 feet long to a tennis ball or sponge. (1) Let a student swing the ball around in a circle. (2) Then let him stand on the end of the string and roll or throw the ball away from him. When the string draws tight, the ball will go in a circle. The string pulls inward on the ball. It acts as a central or centripetal force, keeping the ball at a fixed distance from the center. Students can feel the reaction to this force on the hand holding the string. (3) Now have the student holding the string swing the ball around and then let go. The ball will fly off in a straight line, again, not outward from the one holding the string, but in the direction it was moving at the moment the string was released. It moves along a line that is tangent to the circle.

Newton's Third Law: For every action there is an equal and opposite reaction.

Have a student blow up a balloon and then let it go. What happens? The air (gas) inside the balloon is exerting pressure in all directions. When the balloon is released the air is allowed to escape out one end in one direction. The balloon will travel in the opposite direction.

Have a student put on a pair of roller skates and then throw a ball. The student will move in the opposite direction. Why--because of Newton's Action-Reaction Law.

CHAPTER XV

For what special conditions will a space traveler have to make provisions?

Objectives

1. Why will it be necessary for me in planning a trip to Mars to make mental as well as physical preparations?
2. What perils am I likely to encounter in a space trip that are different from any I have faced on Earth?
3. How will I function differently in a weightlessness environment?
4. How can I demonstrate that melting metal can be used to cool a spacecraft cabin?

15.1 Biomedical Problems

A. Food

Some adjustments for routine daily existence are necessary in space travel. Since there are no super markets in space, man must carry his food with him when venturing far beyond the surface of the Earth. Because gravity does not cooperate with a person trying to prepare a meal in a spacecraft, it will be necessary to do much of the cooking before leaving the Earth. The food is likely to be in bite sized pieces or in strained forms that can be squeezed from a bottle into the mouth. Because space journey will require several days, the food must be prepared in such a manner that it will not spoil. This means most food will have to be sterilized, a process that may change the flavor as well as the nutritional value of the food. All the food carried must be stored in special compartments, and there will be little sympathy for the person who does not eat all that he starts on, since there is insufficient demand for regular garbage collections in space. Among the pleasant features on such a trip will be the fact there will not be dishes to wash, and you will not have to worry about which piece of silverware to use, since it is unlikely you could use either dish or utensil in space.

Perhaps a class discussion will lead to some novel problems. The following questions could be your "blast-off stations." Plan for a round trip to Mars which will take 516 days. Your craft will be carrying a crew of three. Bear in mind that your total food requirement for nearly 18 months must be stored aboard the spacecraft.

1. What constitutes a proper diet? Be sure to include vitamins, minerals, carbohydrates, fats, proteins, and roughage.
2. How many pounds of food must you carry?
3. How are you going to preserve your food?

B. Waste

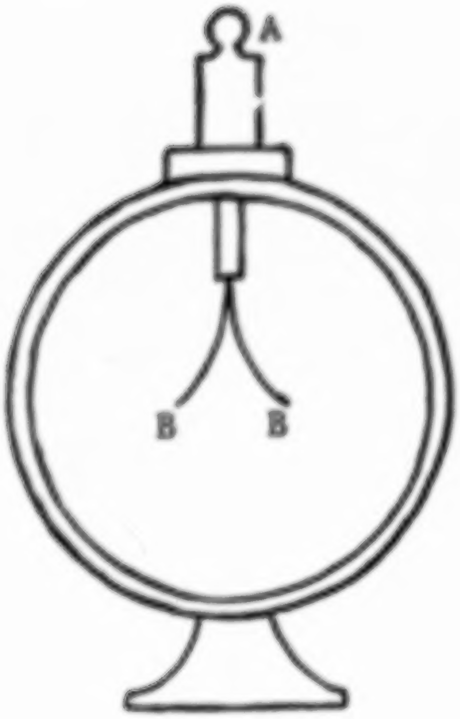
Elimination of waste in space travel presents no serious problem. The researchers at the Air Force School of Aviation Medicine at Brooks Air Force Base have discovered that the urge to eliminate is controlled by gravity receptors on the lower exterior wall of the bladder. Subjects flying in zero-g aircraft flights discovered that the urge to eliminate practically disappears in zero-g, although they have no problem with elimination itself.

What will be done with the urine and feces? Since it will require an excess of three tons of water to provide for bodily requirements alone, it will be necessary to reuse the urine. By controlling the diet it may be possible to reduce substantially the fecal material. That which is produced will probably be used to nourish roughage.

Such practices may seem abhorrent activities to you now, but if you wish to become a space pioneer, you must modify your thinking.

C. Radiation

1. The process by which energy is given off in the form of rays or charged particles.
2. A mode of energy transport whereby energy is transmitted through a vacuum, also the transmitted energy itself, either electromagnetic or corpuscular.
3. There are many kinds of natural radiation that are relatively harmless. Radiation is a threat to safety and life in outer-space travel because it involves possible exposure to harmful radiations which are mostly screened from man on the Earth's surface by the blanket of atmosphere. Man has developed instruments for detecting and measuring radiation. A very simple device for detecting the presence of charged particles is an electroscope. (See diagram on next page).



This electroscope operates on the principle that like charges repel. If the ball, A, at the top of the instrument is charged with electricity, part of that charge is conducted into the metal foil leaves, B. Since the leaves have the same charge, they repel each other and separate. If particles of the opposite charge are attracted to the ball, A, the charge on the electroscope is gradually neutralized, and the leaves come together. The rate of closing the leave measure the rate at which the electric charge leaks from the instrument as a result of ionization in the air.

A radiation counter (for example, a Geiger Counter) is a more sophisticated instrument than the electroscope. It consists of a gas-filled chamber across which an electric field is provided by oppositely charged electrodes on either side. A counter can detect and record these individual charged particles that pass through it with enough energy to ionize the gas within the chamber.

15.2 Meteorites

If one will watch the night sky for any prolonged period, when it is not hidden from view by clouds, he will notice, flaming streaks, flashing across the sky. These are particles of cosmic rock flying through space. Such particles are called meteors while "flashing" across the sky, but if one reaches the Earth's surface, before completely disintegrating it is called a meteorite. There are three distinct groups of meteorites:

1. Those composed or metal, principally iron and nickel are called siderites
2. Aerolites are largely stone
3. Siderolites are made from a combination of stone and metal

Meteors travel at high speeds, since an extremely large percentage of them are burned up before reaching the Earth's surface, the possibility of being injured by one on Earth is slight. However, a person traveling in space does not have our atmospheric protection so the possibility of being struck by one is increased several hundred times.

15.3 Physiological factors

A. Temperature.

Which of two objects is the hotter is determined by direction of movement of heat. Heat always flows from the hotter object to the colder object. Heat is not the same as temperature. Temperature is related to the average speed of molecules; the faster they move, the higher their temperature. Temperature is a measure of the degree of hotness. Heat on the other hand, is a general term meaning quantity of thermal energy. Heat is energy, and temperature is the measurement of the concentration of that energy in a given volume of matter.

The temperature of the air in a spaceship's cabin is easily controlled. The cabin is similar to the inner lining of a thermos bottle which is surrounded by a vacuum. The spaceship's cabin is surrounded by the vacuum of space. Excess heat can be bled off into space by radiation from a black surface on the shady side of the ship. Thus heat presents no serious problem, and even the early unmanned satellites contained devices to control their internal temperatures.

An external part of the spacecraft has shutters that are painted black on one side and white on the other. The shutters are designed to be operated like Venetian blinds and can be used to balance heat input and output by exposing varying amounts of black and white surface to outer space.

B. Weightlessness

Weightlessness is a condition of matter removed from a gravitational field, or produced by balancing gravity and inertia.

Man cannot directly sense the force of gravity. When a person feels the sensation of weight he really feels the resistance of any object that keeps him from plunging toward the Earth's center of gravity. If all resistance to gravity were removed, he would fall freely toward the center of gravity and experience weightlessness, or zero-g. Astronauts experience zero-g in space when a spacecraft's centrifugal force balances the Earth's gravitational pull. Weightlessness will also be experienced by space travelers several hundred thousand miles from the Earth's surface. Compared to the mass of the Earth, the traveler's mass will be very small. When his distance from the Earth becomes sufficiently great the pull of Earth's gravity becomes negligible; thus the traveler will experience weightlessness. Weightlessness can induce dizziness, blood pooling in the legs, loss of calcium in the body, and disorientation, which interferes with the astronaut's ability to perform his job.

C. High acceleration

Acceleration is a change of speed or velocity per unit time. The three main factors involved in human tolerance to acceleration are:

1. The direction of the accelerating force with respect to the human being.
2. The intensity and duration of the acceleration.

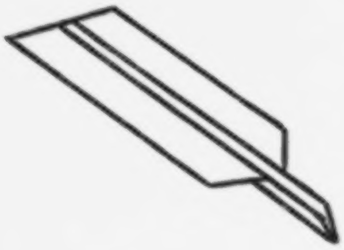
3. The rate of increase of acceleration or the rate of onset. Medical researchers are now studying the acceleration levels and rates of onset required to damage man. The effect of the acceleration of a rocket can be imitated with a contrifuge large enough to carry a man. To imitate the reaching of a certain speed one could use either a very high acceleration, which would not last long, or a lower acceleration, which would require more time. For example, to reach a velocity of 7 miles per second one could accelerate at the rate of 8 g's (either times normal gravity) for 2 minutes and 40 seconds, or one could attain the same speed by accelerating the rate of 4 g's for five minutes and twenty seconds.

15.4 Reentry into Earth's atmosphere

The reentry vehicle can be designed to reduce the effects of pressure and friction by using an ablation shield, which reduces the heat on the surface of the reentry vehicle by melting away. The ablation (or heat removal) shield is designed to absorb much of the heat built up by the compression of air in front of the spacecraft. Drag decay, retrorockets, wings, and parachutes are some of the means used to slow reentry vehicles.

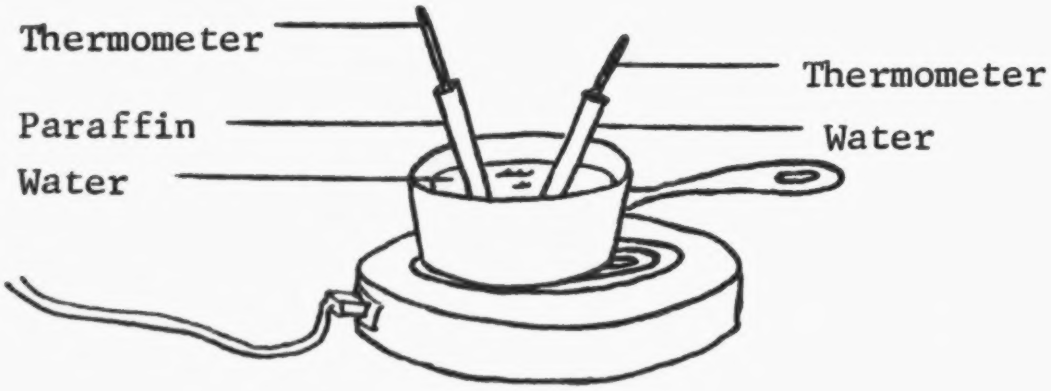
Demonstrations

1. Have students construct gliders by folding sheets of paper. See which glider sails the farthest.



Experiences

1. Have students build models of various shapes of spacecraft. Have them float the various shapes in a tub of water or push them through the sand in a sandbox. As the models are moved forward ripples develop.
2. Have the class melt some paraffin or candle wax and then dip one test tube, nursing bottle, or flask into the wax repeatedly, until a thick coat covers the outside of the container. Place one thermometer in the coated container and a second thermometer in the similar but uncoated container. Add equal amounts of water to each container and place both in a pan of water. Heat the water and observe the relative changes in temperature inside the two containers as they are heated. (The container coated with wax should remain cooler as the wax melts away.) In the same way, the spacecraft will remain cooler as the ablation material melts away.


Thermometer
Thermometer
Paraffin
Water
Water

CHAPTER XVI

What kind of satellites and spacecraft will men use to probe space before sending a man to the moon?

Objectives

1. What benefit have space probes provided for me?
2. Why were our early spaceships so small?
3. Who are our space pioneers?
4. Why have there been so many different space projects?
5. How are we going to investigate the surface of the moon?

The exploration of space is a challenging adventure to man, and almost everyone is caught up in the excitement and expectancy of each new thrust beyond the atmosphere. No one can resist news about a moon probe, a signaling communications satellite, or a man (or men) in orbit around the Earth. All such information concerns aeronautics; the scientific exploration of space. The relationship of the Earth to what lies in space cannot be fully established until man is able to explore the unknown regions; and only by leaving the Earth can he study it and understand it as a part of the complex pattern of the solar system and universe. The kinds of satellites and spacecraft being used in this exciting exploration, in anticipation of sending a man to our lone natural satellite, are studied in this chapter.

16.1 Satellites

A. What contributions have space research satellites made to our knowledge of space?

Space exploration serves man in a great many ways. We have found, and are finding, answers to many questions over which men have pondered for thousands of years. We are acquiring many new and useful materials as by-products of our search for materials suitable for space travel. As a result of planning for space probes, new products for homes, businesses, equipment and products for hospitals have been developed which have improved our living and working conditions and our health.

Space research satellites such as Mariner II have traveled about thirty-five million miles from the Earth, scanned the planet Venus, and sent valuable information about temperatures, radiation, and winds. Research satellites will determine what kind of surfaces planets have and whether some form of life exists on any planet. Astronomers have detected radiations from Mars indicating the presence of hydrocarbon bonds, which in turn indicate the possibility that organic substances exist there. We need to find extraterrestrial life--if there is any and see if we can relate it to our way of life.

The first United States research satellite went into orbit in 1958. It was called Explorer I. A Jupiter C rocket lifted the Explorer I into an elliptical orbit on January 31, 1958. The small satellite weighed only thirty pounds, but it carried many sensitive instruments. Explorer I revealed the existence of two *doughnut-shaped* belts, an inner belt and an outer belt. These bands of radiation are now known as the "Van Allen Radiation Belts." They were named for James A. Van Allen, a physicist who designed the instruments on Explorer I and interpreted their findings.

Other early space research satellites were Explorers II, III, IV, V, VI, and VII, and the Ranger satellites.

B. What advantages are accrued to man by communication satellites?

Much progress is being made in the field of communications. We have many satellites orbiting the Earth, sending radio, television, and telephone signals around the world. Echo I and II are communication satellites designed to reflect radio and telegraph messages from one point on Earth to another. A commercially-owned satellite known as Early Bird is designed to link eighty-five per cent of the telephones in the world, as well as handling two-way television relay teletype, and photographs. Syncom and Advent are satellites that remain "stationary" above the Earth in a 22,300 mile orbit. If three of these satellites were spaced equidistant from each other around the Earth, worldwide transmission would be possible.

Telstar is an "active repeater" satellite that receives, amplifies, and transmits signals received from the Earth. There are also communications satellites which are called "navigation" satellites, because they transmit signals that help ships and planes find their course and position.

C. How are we using weather and observation satellites?

Weather satellites are useful to the meteorologist in weather forecasting and make it possible to report on polar and ocean areas where weather observatories cannot be built. Satellites will make predictions from radar data more accurate. Television cameras carried in these satellites take pictures of cloud formations over great areas of the Earth and transmit this information back to weather stations on Earth. They also are able to measure solar and Earth radiations with infrared devices.

Tiros I was put into orbit on April 1, 1960. Since that time Tiros satellites have produced about 350,000 usable cloud pictures. Both pictures and infrared data are gathered by Tiros. Nimbus satellites are more advanced and will circle the Earth at least once a day and will be able to view every area of the Earth each day. Other weather satellites are Midas, Samos, and Aeros.

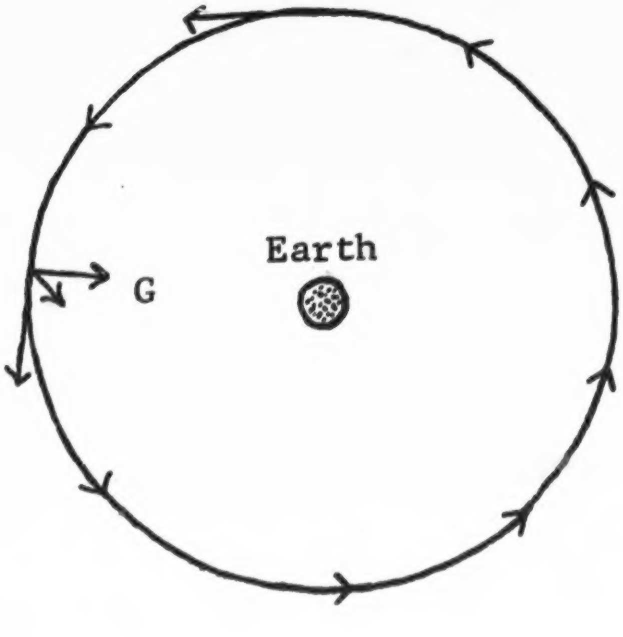
16.2 Exploratory Manned Projects

A. Suborbital manned projects

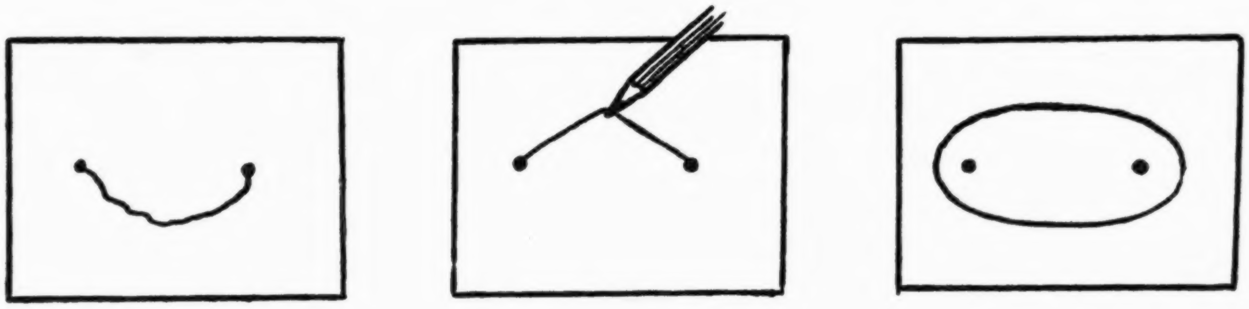
A suborbital flight does not achieve an orbit around the Earth. These flights are sometimes known as high stratosphere flights. The first United States high stratosphere suborbital unmanned flight was a V-2 rocket in 1946 at White Sands, New Mexico. This experimental rocket went approximately 100 miles into space and returned to the desert nearby. The first United States high stratosphere suborbital manned flight took place May 5, 1961, when astronaut Alan B. Shepherd, Jr., was rocketed 116 miles into space and 302 miles out into the Atlantic Ocean.

B. Orbital Flights

An orbit is the path traced by a material body moving through space under the influence of its own inertia, a central force, and other forces. All orbits have one thing in common: a smaller object revolves in space around a larger one. Two requirements must be met before an orbit can be realized. The smaller body must exhibit motion with respect to the larger body, and the two bodies must exert a mutual gravitational pull. An example is the motion of an artificial satellite around the Earth. The satellite must have a minimum velocity of 5 miles per second. The combined effect of the motion of the satellite and the pull of gravity from the Earth is to cause the satellite to move in an almost circular path about the Earth. In a circular orbit, the satellite remains the same distance from the center of the Earth at all times. This is a very difficult situation to attain; most orbits are elliptical.



To draw a diagram illustrating an ellipse, put a sheet of paper on a board and stick two tacks through the paper 4 inches apart into the board. Put a string around the tacks with room to spare. Put a pencil inside the string and draw the figure.



C. Project Mercury

Project Mercury was assigned to the National Aeronautics and Space Administration (NASA) on November 26, 1958. From an early beginning the group evolved into the Manned Spacecraft Center, Houston, Texas. A nationwide call went out for jet pilot volunteers, and seven astronauts were chosen in April, 1959.

The Mercury spacecraft was a one man craft that weighed about 3,200 pounds. It was shaped somewhat like a bell (truncated cone) and was 74.5 inches wide at the bottom and about 9 feet tall. The astronaut escape tower on top added another 17 feet, for an overall length of approximately 26 feet at launch.

For suborbital flights, the booster chosen was the U. S. Army's Redstone rocket with a thrust of 78,000 pounds. Before the manned flights began, a chimpanzee, Ham, made a suborbital flight in Mercury, Redstone 2 (MR-2) on January 31, 1961. On May 5, 1961, MR-3 was sent aloft with astronaut Allen B. Shepherd for a nineteen minute flight. The second suborbital flight was on July 21, 1961, when Virgil I. Grissom piloted MR-4 on a flight almost identical to MR-3.

This concluded the Redstone nonorbital test, and the program that followed consisted of orbital flights with an Atlas booster lifting the Mercury spacecraft into orbit with a thrust of 360,000 pounds.

Again a chimp (Enos) preceded the human astronauts into space in the Mercury-Atlas (M-A-5) program (November 29, 1961).

John H. Glenn, Jr. was the first United States astronaut in space, on a three-orbit flight in M-A-6 on February 20, 1962. He called the spacecraft Friendship 7. Other Mercury-Atlas flights continued to follow until May 15-16, 1963, when astronaut L. Gordon Cooper completed a 22-orbit mission of 34½ hours.

The Mercury project proved that man could be sent safely into space and returned and that man could survive in space for lengthy periods with no harmful effects.

D. The Gemini Project

Project Gemini followed Project Mercury in the space program. Project Gemini was named after the constellation

Gemini, which has two principal stars, Pollux and Castor.

The two-man spacecraft is wider and taller than the Mercury spacecraft and over twice as heavy (11½ feet high, 7½ feet wide, 7,700 pounds).

The Redstone and the Atlas lacked the power necessary to boost the 7,700 pound two-man spacecraft into orbit; therefore a military rocket, Tital II, was modified and prepared as the Gemini Launch Vehicle. The Tital II has 530,000 pounds total thrust, with 430,000 pounds in the first stage.

The Gemini was scheduled to rendezvous and "dock" with a target vehicle. The target vehicle, the Agena-D, was placed into orbit with an Atlas booster. The Agena had an engine that was capable of being ignited, shut off, and re-ignited, making it well suited for this mission.

The first Gemini-Titan test flight (GT-1) occurred on April 8, 1964, as an unmanned flight from Cape Kennedy, Florida. This first Gemini flight had an apogee, or high point, of 204 miles and a perigee, or low, of 99½ miles. The revolution period around the Earth was 89¼ minutes; the velocity was slightly over 17,500 m.p.h.

Gemini had the ability to change speeds, change orbits, turn, and perform other space "firsts." On board the Gemini was a "shoebox" size computer which was extremely beneficial in aiding the astronauts to compute the manuevers necessary for rendezvous and reentering the Earth's atmosphere. The spacecraft also carried a rendezvous radar for determining the distance, angle, and closing speeds of the two vehicles. Visual contact could be made through the use of a large beacon.

Power for the Gemini spacecraft was generated by fuel cells which produced electricity by chemical means. The fuel cells were much lighter than the batteries they replaced. Each of the two fuel cells produced 1,000 watts of electricity, sufficient to supply the total need of the spacecraft.

The Gemini program also produced "space walks" whereby an astronaut could leave his spacecraft and drift through space at the end of a long rope-like line. The Gemini program has been one of the most successful in the total space program to date.

E. Project Apollo

The biggest and most complex of the manned space flight programs is Project Apollo. Project Apollo's objective is to land American astronauts on the moon and bring them safely back to the Earth.

The plan of Project Apollo calls for the Saturn family of rockets (Saturn I, Saturn I B, and Saturn V) to provide power for the flights. The approximate thrust of the combined three stages of Saturn V is 7.5 million pounds. Saturn V will be able to send a 47.5 ton spacecraft to the moon, or a 30 ton spacecraft to Mars or Venus, or place a 140 ton satellite in an Earth orbit.

The Apollo spacecraft itself will consist of three sections: the command module, the service module, and the lunar excursion module.

The command module will weigh about five tons, stand twelve feet tall, and be thriteen feet in diameter. It will accommodate three astronauts in a pressurized capsule, permitting them to carry out their duties without the hindrance of space suits. The capsule will be fitted with navigation control instruments, allowing the crew to guide the craft's reentry into the Earth's atmosphere at the end of the mission.

The service module will weigh twenty-five tons and measure twenty-three feet long and thirteen feet in diameter. It will be equipped with rockets and a fuel supply adequate for leaving Earth orbit and establishing lunar orbit--and the subsequent return from lunar orbit to Earth.

The lunar excursion module, or LEM, will accommodate two astronauts for the actual landing mission. It will be equipped with rockets for escaping the lunar orbit, retro-rockets for effecting the landing on the moon's surface, and rockets for lift-off from the moon and return to the service module. Five spider-like legs will support the LEM while it is on the moon.

The launch of Saturn V will mark the beginning of Apollo's lunar exploration mission. The entire assembly will stand 364 feet high and weigh six million pounds at launch. The first two stages and part of the third will be used to place Apollo in orbit around the Earth. At the proper position and time for achieving a lunar trajectory, the third stage will be refired and the remaining assembly accelerated to about 25,000 m.p.h.

When the fuel of the third stage has been exhausted, the crew will disconnect the command and service modules as a unit and reconnect them so that the command module is nose-to-nose with the LEM. As the craft nears the moon, it will be rotated to a tail-forward position and a rocket in the service module will be activated, placing the craft in a circular orbit about 100 miles above the moon's surface.

Two of the astronauts will then enter the LEM, disengage it from the rest of the craft, and pilot it to the moon's surface. Upon landing they will actually leave the LEM and explore the vicinity of their landing site, taking photographs, collecting samples, and performing scientific experiments. Subsequent to their moon explorations they will reenter the LEM, lift off from the moon, and return to a rendezvous with the service module where they will rejoin the remaining astronaut. The LEM will be jettisoned and the rockets of the service module activated for the journey back to Earth.

Entering the Earth's atmosphere will be one of the most critical aspects of the return trip. The spacecraft will have an Earth approach velocity of 25,000 m.p.h. and must follow an extremely precise course--known as an entry corridor--to avoid swerving back into space or being burned up from the extreme friction encountered. The crew will actually navigate from the command module in order to achieve this entry corridor, where searing heat and the deceleration forces of the atmosphere will begin.

After successful reentry into the Earth's atmosphere, a small parachute will open, followed by a large one. These chutes will help stabilize the craft and slow it to its proper landing speed. After splash-down, the craft will be recovered and the crew "debriefed," and an evaluation will be made of the material collected, the photographs taken, and the experiments performed on the moon.

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